Shipping Doors — A State of Practice Review

A RESEARCH REPORT

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Energy Conservation and Oil Substitution Branch
Energy, Mines and Resources Canada

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The Buildings Energy Technology Transfer Program (BETT) of EMR has been created to assist building owners, users and practitioners active in the design, construction and operation of buildings in identifying technical obstacles to energy conservation. Through a nationwide network of research agencies and private sector consultants, BETT carries out research and development projects and provides the audiences mentioned above with technical reports, how-to manuals, training manuals, audio-visual aids and data bases to help them overcome these obstacles.

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ABSTRACT/RESUME

This report reviews the nature and use of shipping doors in warehouse and light industrial buildings. Emphasis is placed on energy-related considerations and the potential for conservation. Both the trade and technical literature are reviewed. A field survey of representative door installations is documented.

An important conclusion is that shipping doors, both existing installations and new products, are prime targets for energy conservation. Attention should be focussed on reducing air infiltration. There appears to be a need for an energy analysis procedure for shipping doors that could be accepted and used on an industry-wide basis.

* * *

Le présent rapport porte sur les caractéristiques et l'emploi des portes des quais d'expédition des entrepôts et des bâtiments de l'industrie légère. Il traite surtout des considérations touchant la consommation d'énergie et des possibilités d'économie dans ce domaine. On y présente les résultats d'une analyse de la documentation technique et publicitaire sur le sujet, ainsi que les conclusions d'une étude sur le terrain d'un échantillon représentatif des divers types d'installations.

Il ressort clairement de ces données que les portes des quais d'expédition, tant les modèles en place que les nouveaux modèles offerts sur le marché, sont des cibles de premier ordre pour quiconque désire améliorer le rendement énergétique de son entreprise. Il faudrait s'efforcer avant tout de diminuer l'infiltration d'air. De plus, il semble nécessaire d'instituer pour toute l'industrie une méthode uniforme d'analyse du rendement énergétique des portes installées aux quais d'expédition.

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The Buildings Energy Technology Transfer Program (BETT) was initiated by the Department of Energy, Mines and Resources (EMR) of the Government of Canada in late 1981. The principal objectives of this program are:

- to identify the potential for energy conservation in both new and existing buildings
- to determine R, D and D requirements and their priority in order to exploit this potential
- to perform and/or expedite the necessary R, D and D
- to effectively transfer the necessary technology to the appropriate individuals, groups or agencies
- to provide technological support to EMR in the development of policy and programs.

The Building Engineering Group (BEG) was selected* by EMR to develop and execute a comprehensive R, D and D program for energy conservation in the warehousing and light industrial building sector. BEG is a semi-autonomous, non-profit agency associated, through the Waterloo Research Institute (WRI), with the University of Waterloo. This multi-disciplinary group seeks to provide a comprehensive range of R and D services to the building industry.

The warehouse and light industrial building (WLIB) sector is particularly important because:

- the square footage of building space involved is extensive: over one billion square feet.
- to date very little R and D, energy-related or otherwise, has been directed towards this building category
- the nature of these buildings, both new and existing, makes them particularly amenable to some degree of energy conservation.

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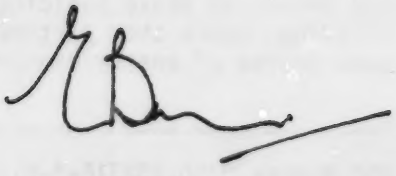
* DSS Number 02SQ.232316-3-6111 Serial Number OSQ83-00001 and Proposal Number WRI 109-01, September 20, 1981.

One of the major contributors to energy consumption in WLIBs are the shipping doors whether closed or open. Accordingly, two related tasks on shipping doors were initiated. A report, entitled "Industrial Service Doors - A Review", and a companion report, entitled "A Test Facility and Procedure for the Measurement of the Air Leakage Characteristics of Installed Shipping Doors", were the products of these two tasks. This report entitled "Shipping Doors - A State of Practice Review" is essentially the first five chapters of the first report.

Much of the work involved in conducting the field survey and liaising with the door industry was done by John McGlashan. In addition, assistance was provided by Mehdi Bahadori, Michael Louwen and other members of the Building Engineering Group.

This report is one product of a comprehensive multi-year program of research, development, demonstration, dissemination and evaluation. Given the size of the shipping door industry and the ubiquity of shipping doors, there is relatively little non-proprietary information available. This report, we believe, is unique in that it attempts to provide an overview, albeit from an energy perspective, of the use of shipping doors in Canada.

We are aware that certain topics, e.g., the size and nature of the shipping door industry, are only touched upon. It is our opinion that additional R and D is warranted. This report can be improved, especially with input from the door industry. Feedback with regard to the report or related issues is welcomed and should be directed to the undersigned.



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This study could not have been conducted without the co-operation and assistance of numerous door manufacturers and distributors. Their interest and willingness to supply information is much appreciated. This report contains numerous figures, photographs of buildings and several diagrams of details taken from the trade literature. We have avoided identifying individual companies, but we would like to generally acknowledge our use of this material. We would also like to acknowledge the assistance of the Canadian Door Institute, especially Mr. Lee Bauman. Finally, the sponsor, Energy, Mines and Resources, is to be commended for supporting and funding this study.

1.1 BACKGROUND

Warehouses, light industrial buildings, and many other types of buildings are usually equipped with one or more large doors to permit the transshipment of goods and sometimes people. These industrial or commercial service doors are usually referred to as shipping doors. Depending upon need and volume, the number of doors required for shipping and/or receiving may range from one multi-purpose door to more than a hundred single-use doors. In the latter case the facility may well have a sophisticated trans-shipment system, involving automated scheduling for traffic (and thus opening and closing of doors) and specific measures to maintain comfort levels, ensure adequate air quality, and minimize energy costs.

Like windows and "person" or man doors, shipping doors constitute discontinuities in the building enclosure. As they are somewhat larger than windows or man doors, their influence on energy consumption - both when closed and especially when open - is likely to be even more significant. When closed, both transmission and air leakage heat losses may be important contributors to space heating energy consumption. In winter an open door, or more significantly a combination of open doors, can have an immediate impact on comfort levels and space heating energy requirements. In summer, shipping doors can be opened to augment natural ventilation for cooling purposes and to provide daylighting.

While there is a great deal of trade literature, there is not much technical information on shipping doors. Moreover, there appears to be little, if any, non-proprietary data on the actual performance of shipping door installations, particularly their energy related performance. This study was initiated in order to gather the available information and assess the energy related significance of shipping doors.

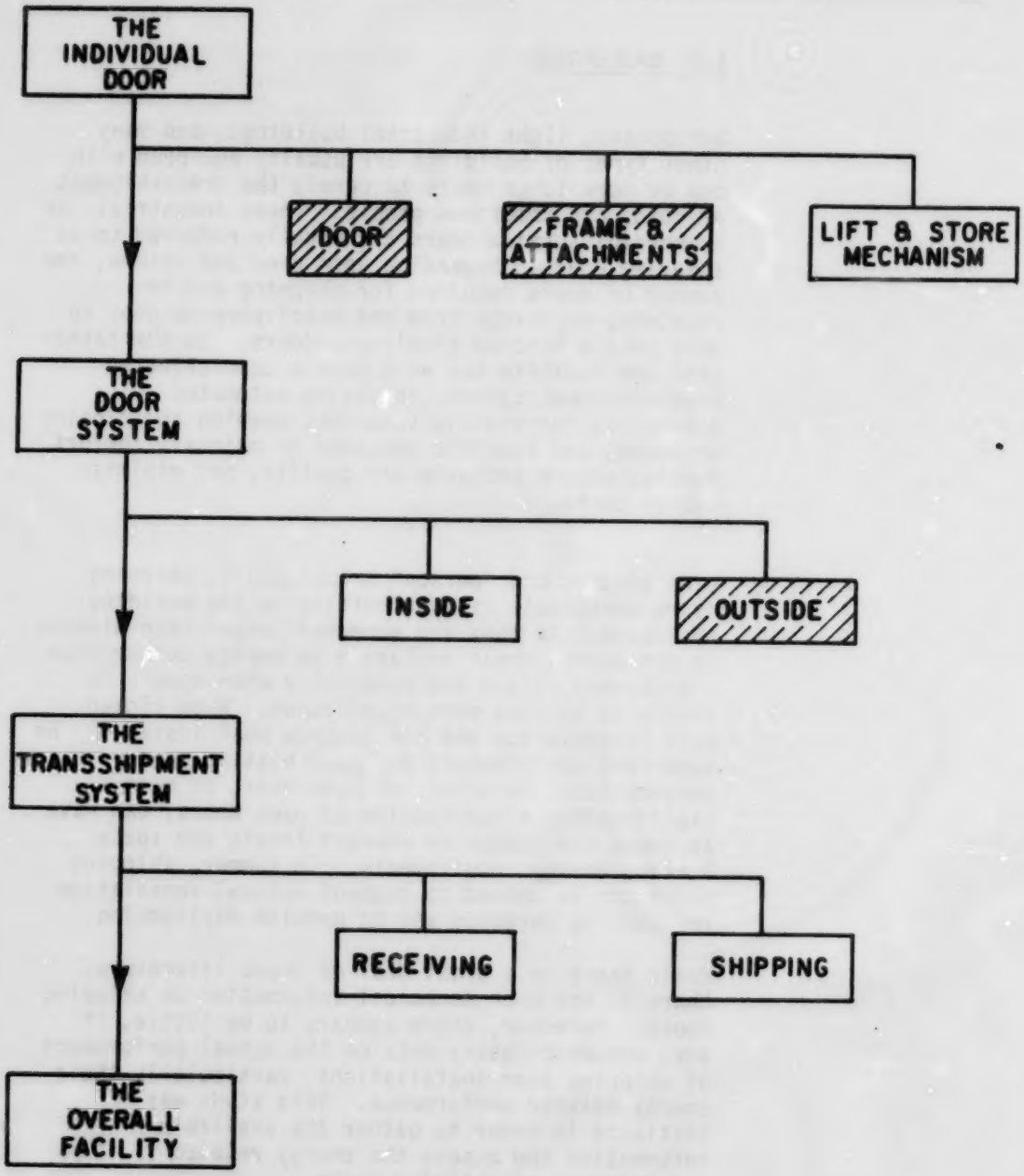


FIGURE 1.1: INDUSTRIAL/COMMERCIAL SERVICE DOORS - LEVELS OF CONSIDERATION

1.2 OBJECTIVES

This report is intended as a state-of-practice overview of industrial service doors. Specific objectives are as follows:

- to review the available literature on shipping doors including both product and technical information.
- to do a field survey to obtain some idea of actual practice, i.e., the types of doors actually used and their condition.
- to identify the performance attributes of shipping doors with particular reference to energy considerations.

1.3 SCOPE

In the overall scheme of things, it is likely that neither shipping doors nor energy conservation are overwhelmingly important to the owner or operator of a building. In their view shipping doors are necessary devices to permit the trans-shipment of goods; energy is a necessary part of the cost of doing business. However, taken in context and given the right opportunity and time frame, both shipping doors and the related consumption or conservation of energy are important. Some indication of this context is illustrated in Figure 1.1, where the various levels at which shipping doors need to be considered are listed. In this report, the individual door and specific aspects of its operation are considered in some detail (i.e., the shaded items in Figure 1). Larger issues such as traffic flow, the mechanics of shipping and receiving, etc., are not considered in any detail.

This study is limited in scope to a synthesis of existing practice. It was thought that the subject needed to be comprehensively reviewed and understood before any needed R and D is undertaken, if indeed any is needed.

2.1 METHOD

The objectives of surveying the commercial literature were:

i) to quickly obtain some idea of the nature of shipping doors, e.g., the number of suppliers, types of products, range of products, and

ii) to establish what products are currently being sold, what the current market trends are and what developments are likely to occur.

To initiate this work, brochures and related trade information were solicited from local distributors and installers. A library of door-related information was started. Contact was made with the Canadian Door Institute; their annual trade show provided an excellent opportunity to meet with most of the major Canadian manufacturers or distributors.

A fairly comprehensive mailing list of Canadian shipping door and ancillary equipment suppliers was then compiled. Each supplier was asked to provide product literature, test reports and results, price lists, market analysis, and any other relevant documentation. The response was fairly enthusiastic, and some of the material received is synthesized in the sections that follow.

2.2 MANUFACTURERS AND DISTRIBUTORS

An extensive list of manufacturers and distributors of shipping doors is provided in Appendix A. The door industry market in Canada is about $40-$50 million per year. The size of the door repair, retrofit and maintenance portion of this business is not known. The business is fragmented and competitive - there are many manufacturers in Canada and there is very strong competition from US and European manufacturers.

2.3 PRODUCTS

2.3.1 Shipping Doors

Shipping doors may be categorized by the nature of the door, as follows:

A. Sectional Overhead Doors: Sectional overhead shipping doors (Figure 2.1) most resemble residential garage doors. They are composed of a number of horizontal sections mounted on the upward-acting, roller-track mechanism. The track allows the door to be lifted to an overhead storage position (hence the name). The door may be stored in a vertical, an inclined or a horizontal position and may be stored at any level. Sectional overhead doors may be sub-categorized by door profile into panel type and flush type (Figure 2.2). Sections are typically 600 mm (2 feet) in height and can be made of wood, steel, aluminum, fibreglass or plastic. The flush-type profile is easiest to insulate. In existing buildings, wooden sectional overhead doors are by far the most common, due primarily to their low initial cost.

B. Rolling Doors: Rolling doors (Figure 2.3) are constructed of interlocking pre-formed slats. Many different slat profiles are available, in varying shapes and thicknesses (Figure 2.4). As the name implies, the door rolls up around a drum within a protective hood. Very little storage space is needed, making this type of door popular when space is limited. Usually only a deep "C"-shaped track, mounted on the sides of the door frame, is needed to act as a guide for the door. It is the easiest of all types of shipping door to install. Typical materials are aluminum, steel and stainless steel of varying gauges, depending on the width of the opening. Insulated slats are now available. The door is usually counterbalanced with torsion springs.

C. Vertical Lift Doors: Vertical lift doors consist of single or multi-bladed sections which rise in vertical tracks (Figure 2.5). Blades run in parallel tracks. The blades

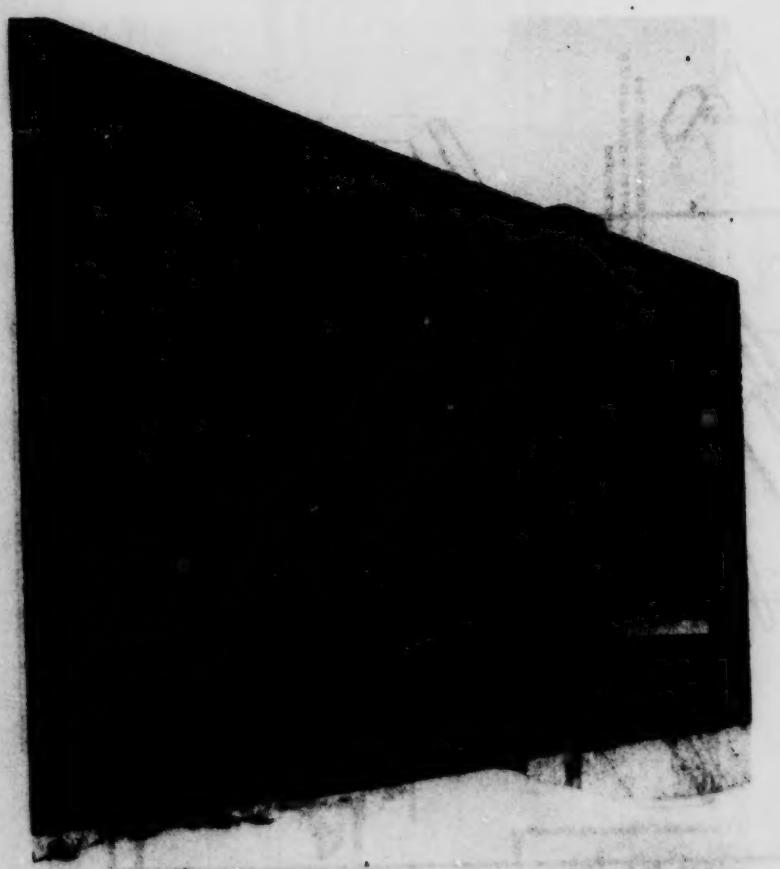


FIGURE 2.1: A TYPICAL SERVICE OR SHIPPING DOOR

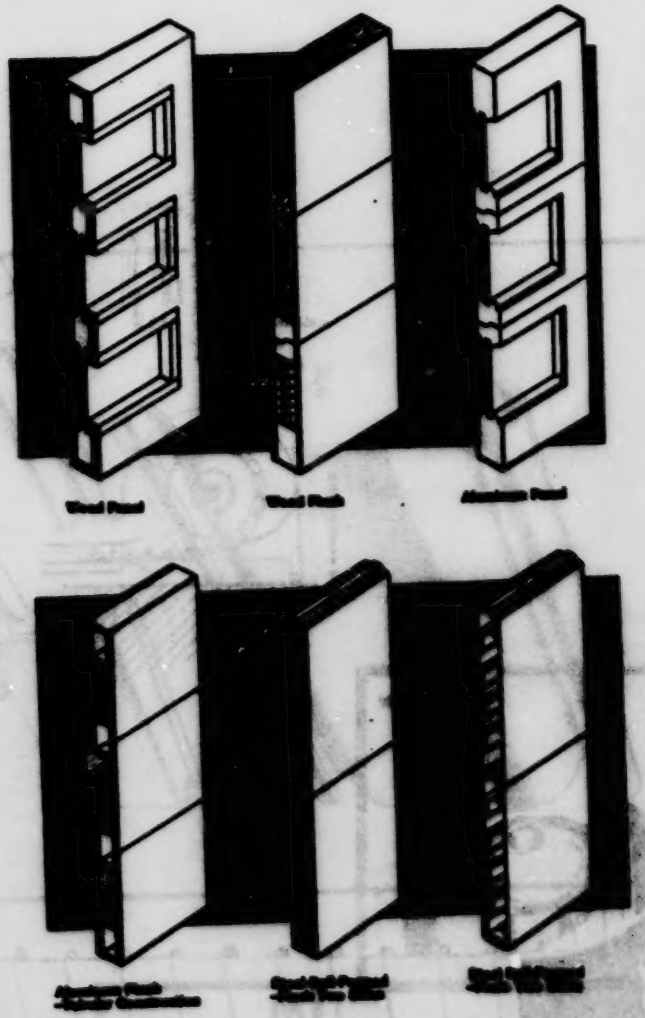


FIGURE 2.2: TYPES OF DOOR CONSTRUCTION

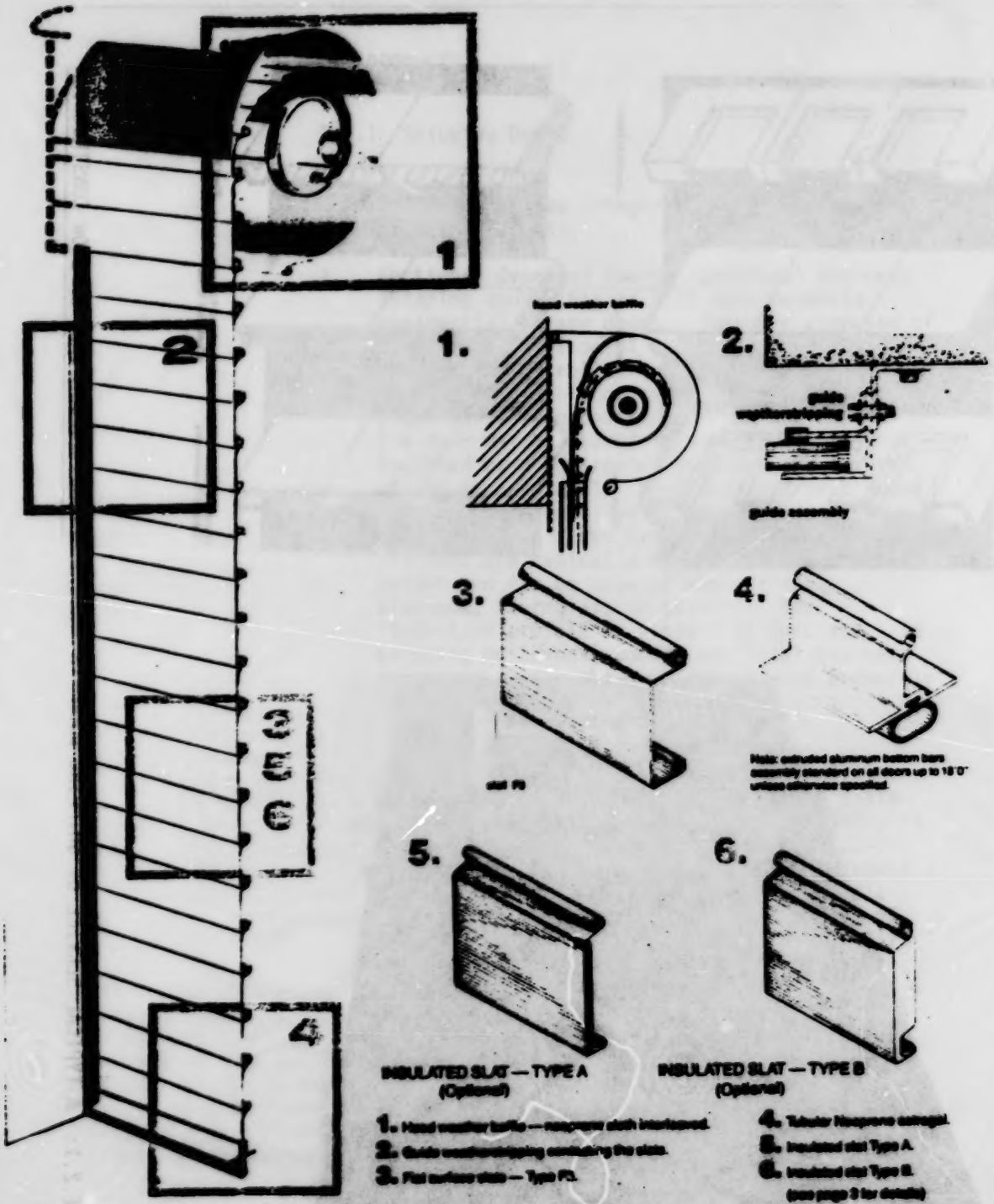
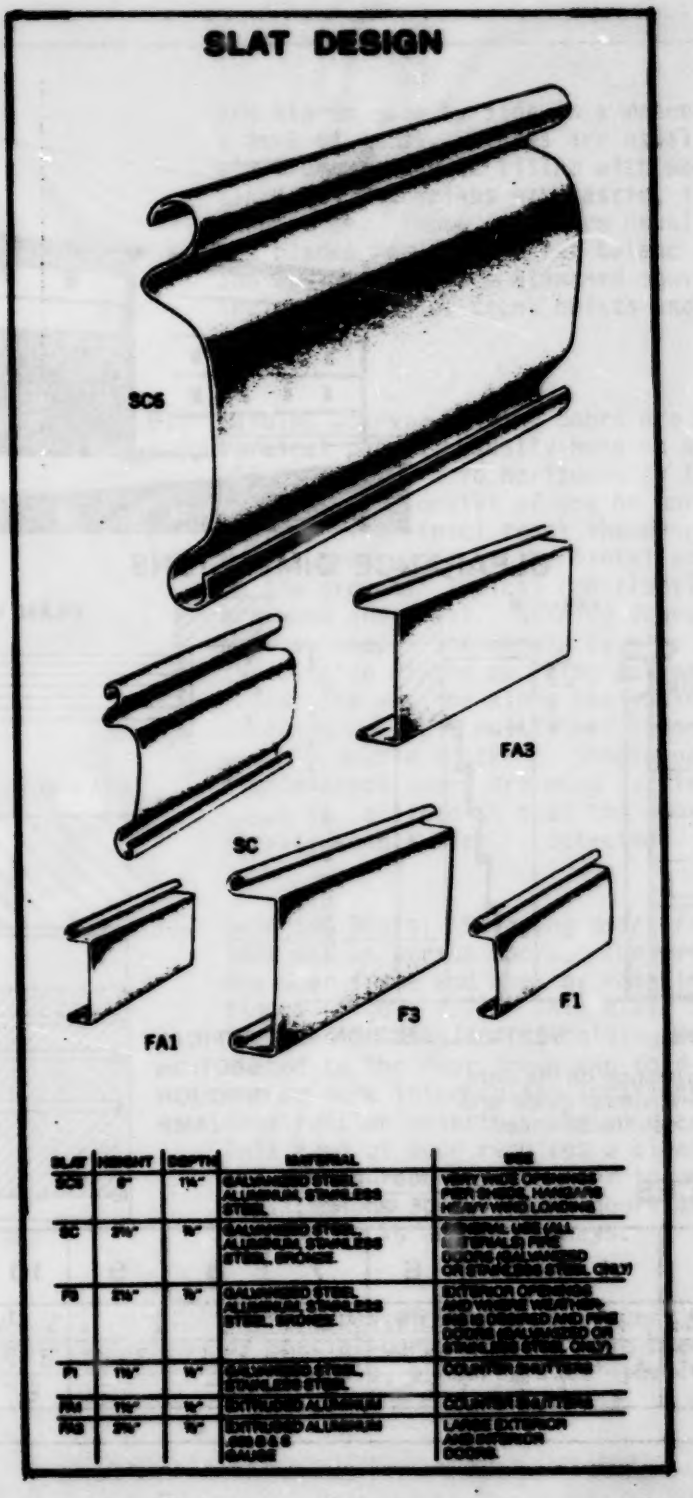


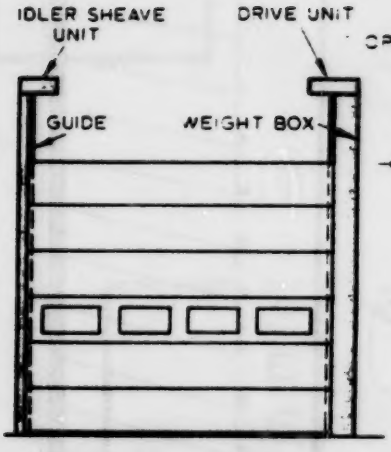
FIGURE 2.3: ROLLING DOORS



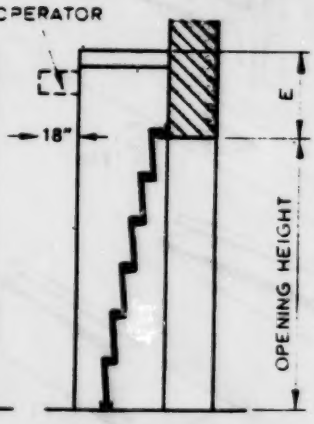
SLAT	HEIGHT	DEPTH	MATERIAL	USE
SC6	6"	1¼"	GALVANIZED STEEL, ALUMINUM, STAINLESS STEEL	VERY WIDE OPENINGS FIRE BRIGDE, HANGARS HEAVY WIND LOADING
SC	3½"	¾"	GALVANIZED STEEL, ALUMINUM, STAINLESS STEEL, BRONZE	GENERAL USE (ALL EXTERNAL FIRE DOORS ARE MADE OF STAINLESS STEEL ONLY)
F3	3½"	¾"	GALVANIZED STEEL, ALUMINUM, STAINLESS STEEL, BRONZE	EXTERIOR OPENINGS AND WHERE WEATHER AND IS DESIRED AND FIRE DOORS (GALVANIZED OR STAINLESS STEEL ONLY)
F1	1½"	¾"	GALVANIZED STEEL, STAINLESS STEEL	COUNTER SHUTTERS
FA1	1½"	¾"	EXTRUDED ALUMINUM	COUNTER SHUTTERS
FA3	3½"	¾"	EXTRUDED ALUMINUM ,GRS 5 & 6 GAUGE	LARGE EXTERIOR AND INTERIOR DOORS.

FIGURE 2.4: ROLLING DOOR SLATS

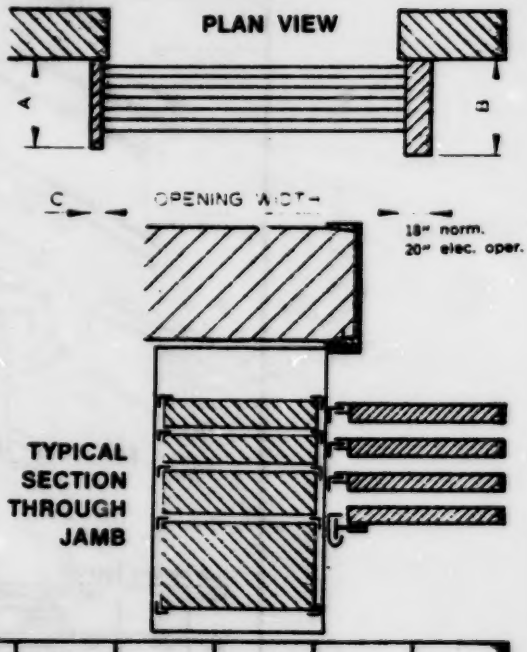
CLEARANCE DIMENSIONS



INTERIOR ELEVATION



VERTICAL SECTION



TYPICAL SECTION THROUGH JAMB

As can be seen in the illustration on the right, each blade runs on an individual guide and is independently weight counterbalanced.

DOOR CLEARANCES

*PITCH = $\frac{\text{OPENING HEIGHT}}{\text{NO OF BLADES}}$

NO OF BLADES / DIMENSION	3	4	5	6	7	8	9	10	11	12
"A"	1'-4 3/4"	1'-7 3/4"	1'-10 3/4"	2'-1 3/4"	2'-4 3/4"	2'-7 3/4"	2'-10 3/4"	3'-1 3/4"	3'-4 3/4"	3'-7 3/4"
"B"	1'-10"	2'-1"	2'-4"	2'-7"	2'-10"	3'-1"	3'-4"	3'-7"	3'-10"	4'-1"
"C"	6"	6"	6"	6"	6"	6"	6"	6"	6"	6"
"E"	PITCH* + 1' 8"									

FIGURE 2.5: VERTICAL LIFT DOORS

are stored side by side in a manner resembling a deck of cards. Blades are usually steel or aluminum but may be filled with wood, steel, aluminum, fibreglass or plastic, together with insulation. These doors are usually heavy, and the blades require counter balancing for safe and easy operation. Standard equipment includes chain or crank hoists and counter balancing.

D. Sliding Doors: Sliding doors are made of vertical panels, usually hung on a track that allows them to move horizontally (Figure 2.6). The door may consist of one or more panels. Instead of a lintel track the doors may have a double track, one at the lintel and the other on the ground. Typical construction materials are wood and steel. Sliding doors may easily be insulated. The panels usually slide along the outside of the building but may also slide inside the wall or along the inside of the building. Large, multi-leaf hanger doors are usually double tracked. Single-panel, single-track doors are used as fire doors. The track is inclined so that the door closes by gravity when a fire is detected.

E. Swinging Doors: Swinging doors function in the same way as person doors. They are hinged to the door frame and open by rotating about these hinges (Figure 2.7). This class of door also includes folding and bi-folding doors that are hinged to the door frame and fold inwards at one or more intermediate locations. Typical construction materials are wood and steel. This type of door requires a clear swing path and enough room for the door to open. Typical applications for swinging doors are small loading docks and crane-ways.

F. Other types of Doors: In recent years a number of special-purpose doors have been developed. For example, a door system* involving a

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* "door system" is used to refer to the door, its frame and all attachments.

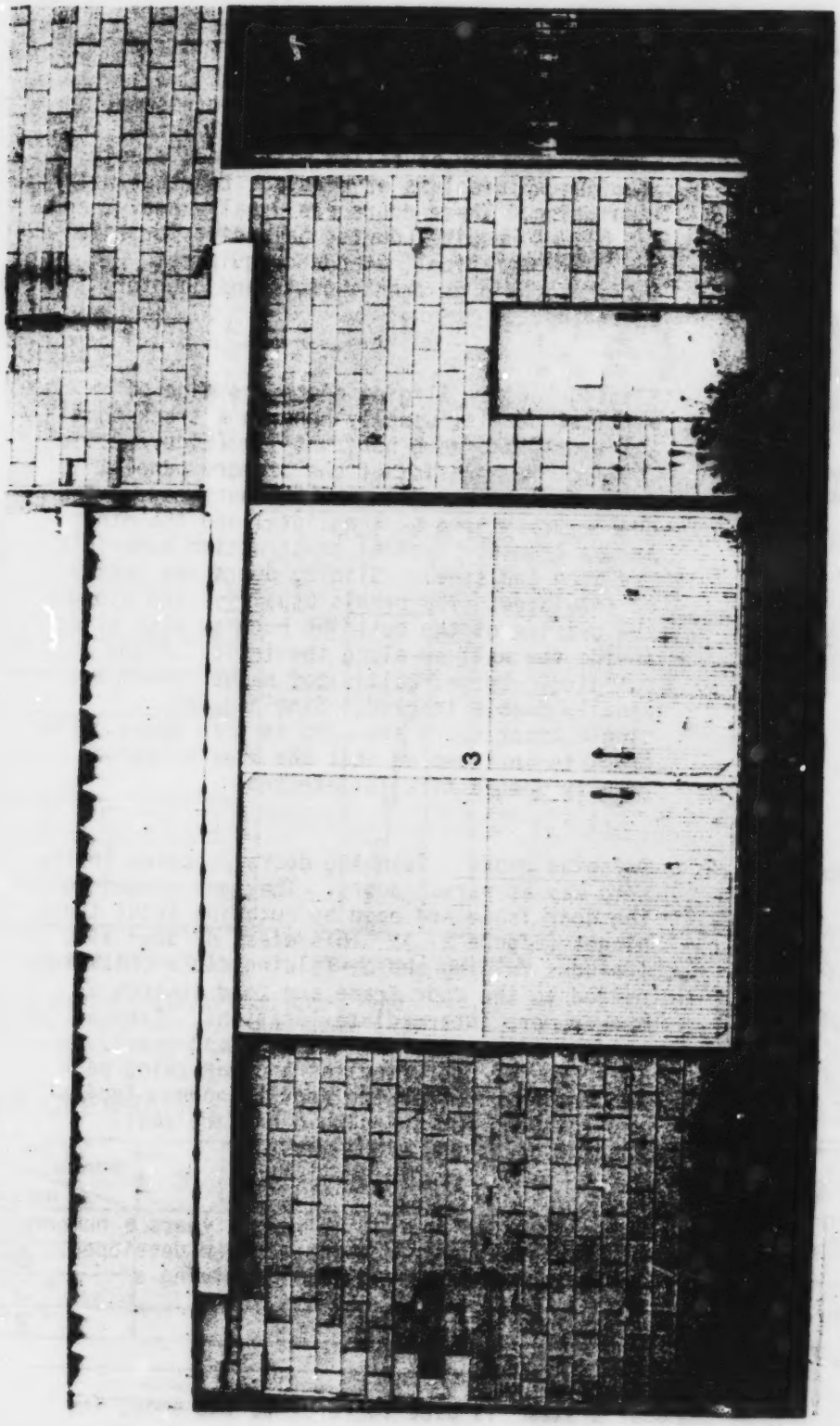


FIGURE 2.6: A SLIDING DOOR

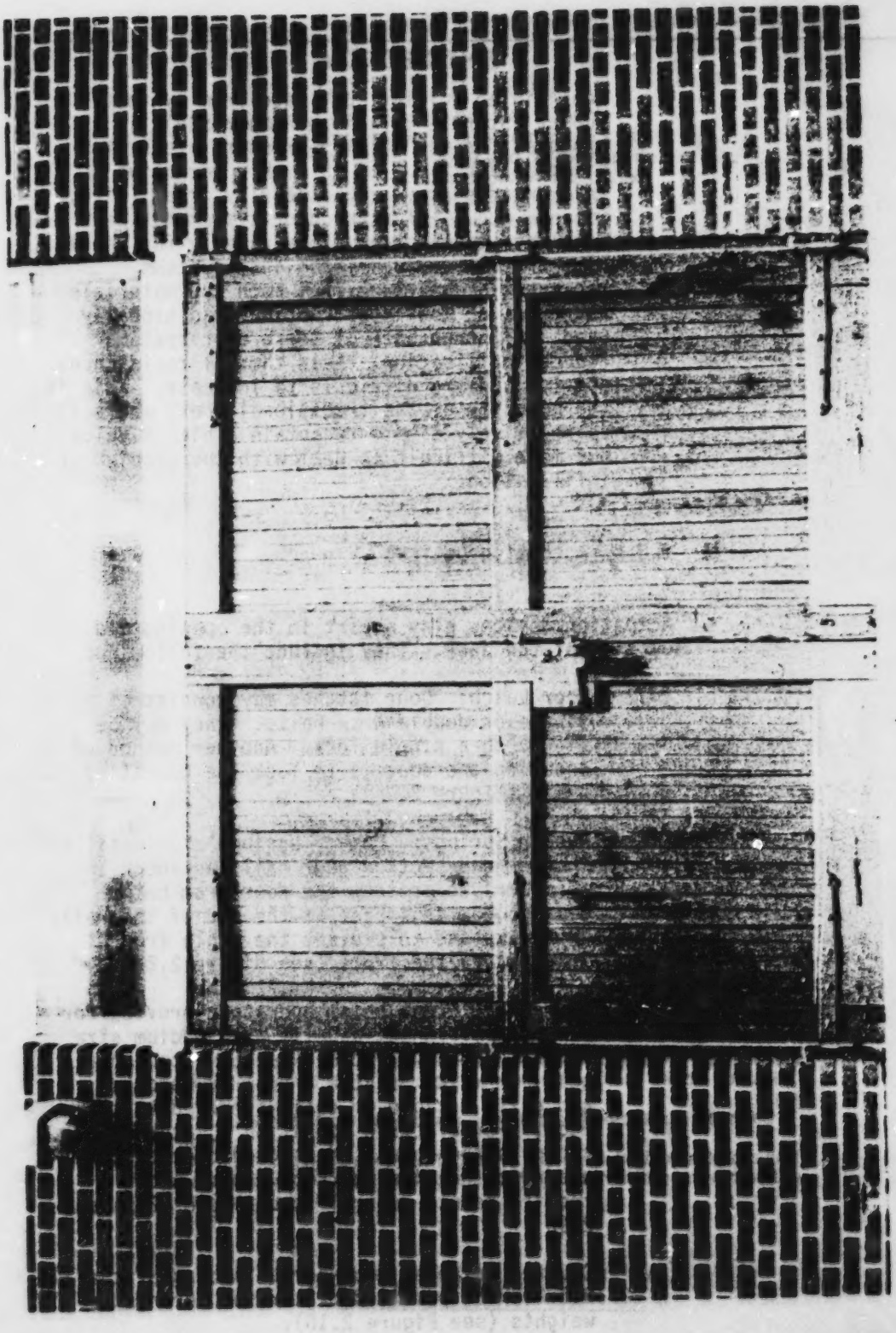


FIGURE 2.7: A SWINGING DOOR

non-jointed rolling door made from synthetic rubber (Styrene Butadiene Rubber-SBR), is produced for use in high-pressure areas (to minimize air flow) or in highly corrosive environments or in high security areas (fire, impact, etc.). Another door system has been developed to open and close rapidly for use in high traffic areas. These door systems represent a departure from both the materials and types of door construction traditionally used. Although both of these door systems reduce infiltration, their thermal resistances are low and are difficult to increase. This is the opposite of the traditional door, where it is relatively simple to obtain a high R value but more difficult to deal with the problem of infiltration.

2.3.2 Actuation Devices

Actuation devices play a part in the opening and closing of the door. They include the following:

(i) Door Latch: Door latches may consist of single or double draw bolts. They may be linked to a single lock. Another method of securing the door is to lock the operating chain (Figure 2.8a).

(ii) Pusher Springs: Pusher springs are installed in overhead section door rails as shock absorbers to protect the door from being damaged due to impact at the end of the rails or tracks and to prevent the cable from jumping off the drums (see Figure 2.8b).

(iii) Operator: Crank hoist operators provide for manual assistance, usually with medium size doors. A chain or crank is connected to a gear box which rotates a drum or sprocket and pulls a cable or chain attached to the door. For electric operation a motor may be added to the hoist. Motorized operation is used with heavier doors or doors which require remote control (see Figures 2.9a and 2.9b).

(iv) Counter Balance: Counter-balancing of the door can be provided by torsion springs or weights (see Figure 2.10).

ACROSS THE DOOR BAR LATCH

Doors may be fitted with a double point inside bar latch. A night lock with an outside cylinder and handle may be used for manual doors. When latches are used on electrically operating doors an electrical interlock switch is recommended to prevent damage to the electric operator.

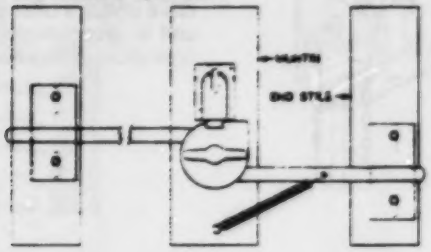
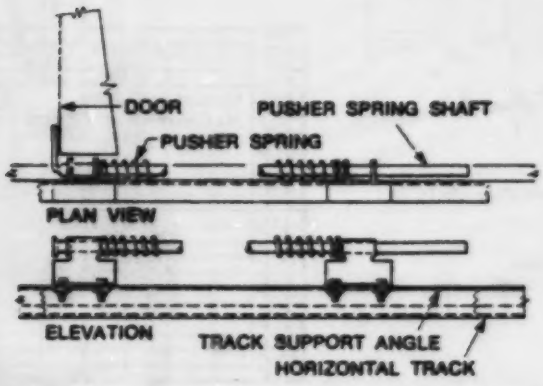


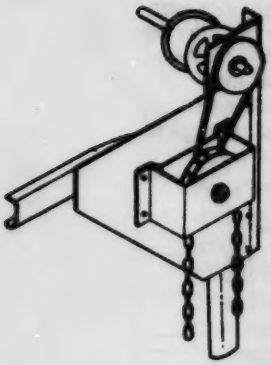
FIGURE 2.8a: DOOR LATCH



PUSHER SPRINGS

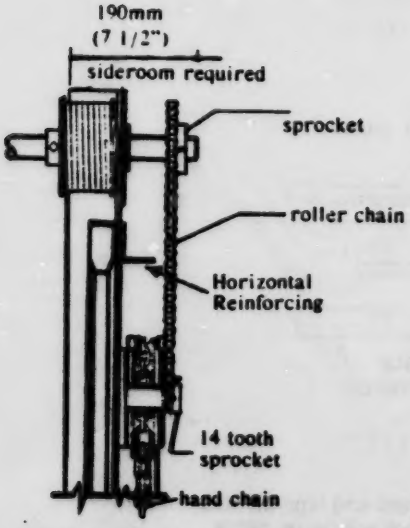
The addition of pusher springs to all standard-lift sets and high-lift sets with less than 3'-0" of headroom ensures that there will be no cable jumping.
This applies to both hand chain operated and electrically operated doors.
The pusher springs are mounted to the rear of the horizontal tracks and actually push the door on the closing cycle, maintaining tension on the cables.

FIGURE 2.8b: PUSHER SPRINGS



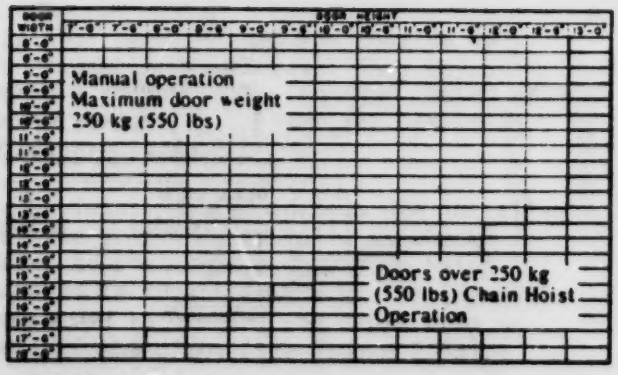
HAND CHAIN HOIST

Use of a hand chain hoist is recommended for doors weighing over 350 lbs. and for doors over 10'-0" high regardless of weight. Both a reduction unit and a direct drive unit are offered. The reduction unit is recommended for ease of operation and smooth action.



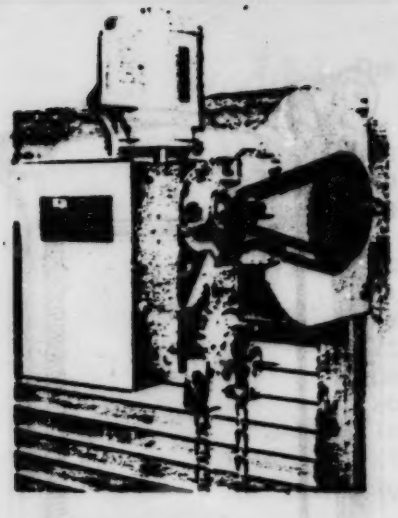
Type "A" - shown
Type "B" - Mounted underside of horizontal reinforcing

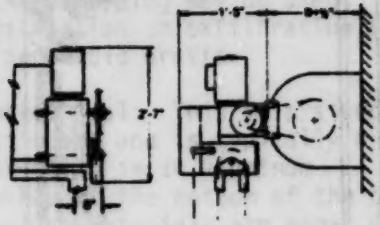
Type "C" - Wall mounted
Type "D" - Special "disconnect" type

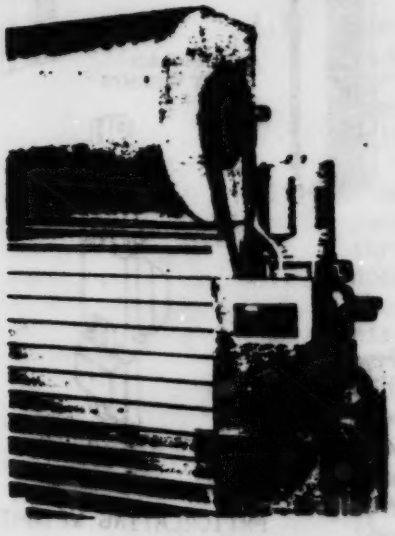


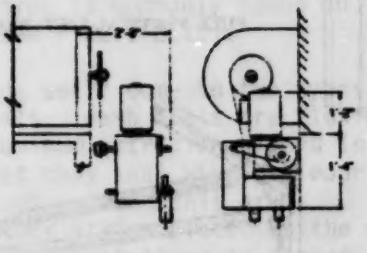
Chain Hoist:

FIGURE 2.9a: CHAIN HOIST OPERATOR









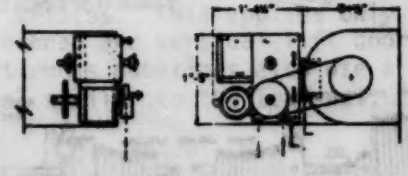


FIGURE 2.9b: ELECTRIC OPERATIONS

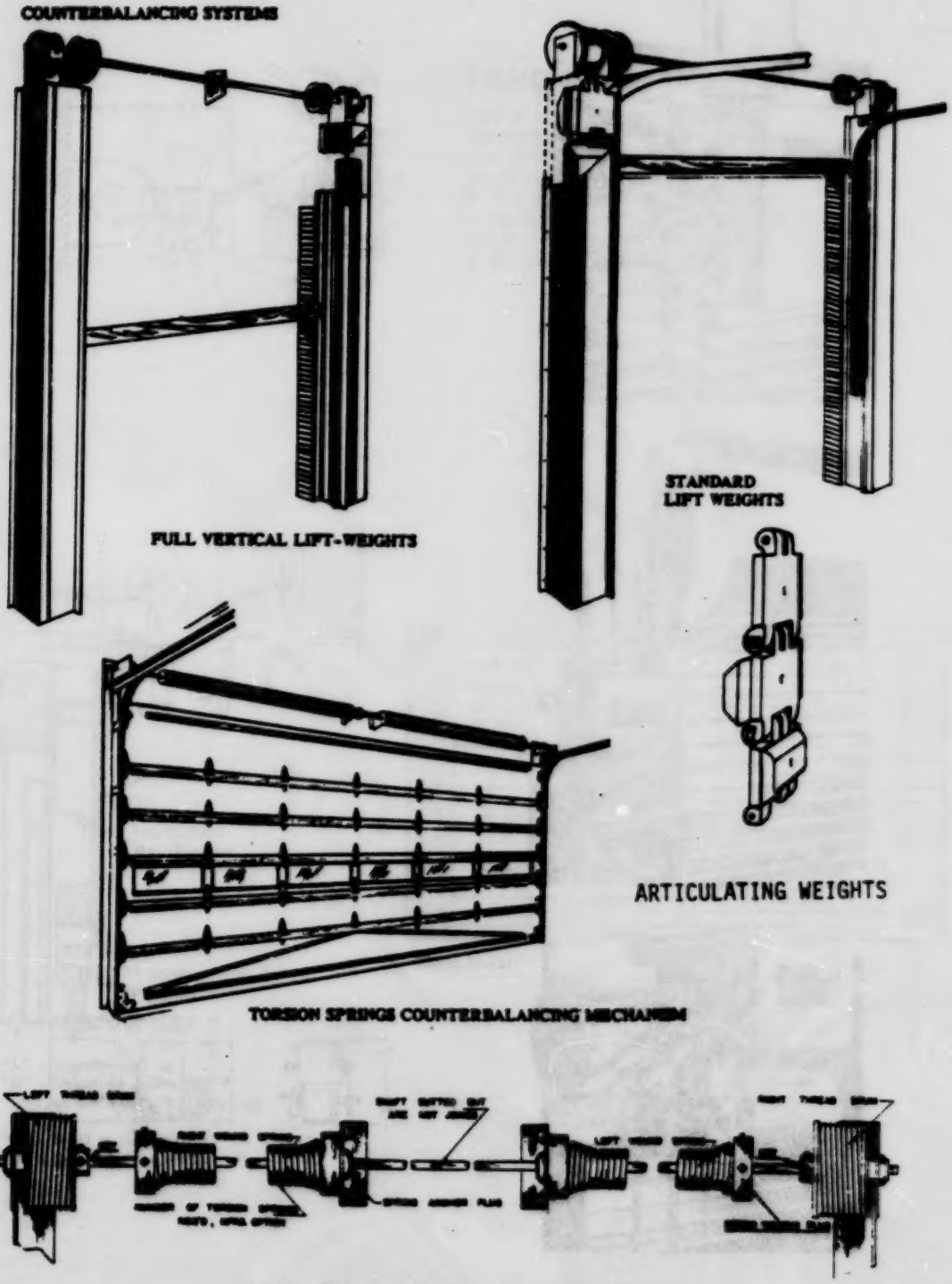


FIGURE 2.10: COUNTERBALANCING SYSTEMS

2.3.3 The Door-Frame Interface

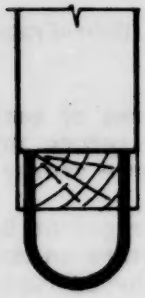
Various forms of weatherstripping may be used, largely to reduce infiltration or exfiltration and thus conserve energy and avoid drafts.

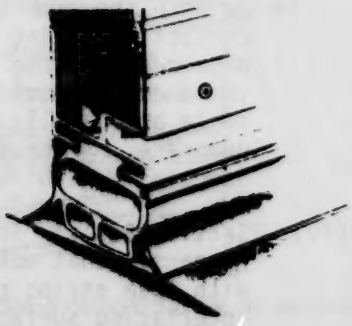
(i) Astragal or Bottom Seal: This is a standard feature on most doors and is typically a U-shaped rubber strip in an aluminum extrusion attached to the bottom of the door. Common construction materials are vinyl or neoprene. Options include pneumatic or electric switching devices for use as a safety feature or for automatic control (see Figure 2.11).

(ii) Top Seal: A flexible vinyl or neoprene strip is used to butt against the header to prevent air infiltration. Brush-type seals can be used, and this type is commonly found on rolling doors (see Figure 2.12).

(iii) Side Seals: Side seals come in two types - jamb or door seals. Jamb seals are flexible strips in an aluminum extrusion placed in the door jamb so that they seal when the door is closed on the jamb. Door seals are essentially weather strips placed on the door or onto the jamb so that there is direct contact. Rolling doors, for example, can use door seals on the inner and outer surfaces of the door to provide double protection. Side seals are usually made from vinyl or neoprene, but brush systems are often used, especially with rolling doors (Figure 2.13).

(iv) Section Seals: The gap between the sections or panels that make up the door can be sealed with foam strips placed on one of the interfacing surfaces. This applies only to sectional overhead and vertical lift doors. Vertical lift doors sometimes also use a sectional seal similar to the top seal.





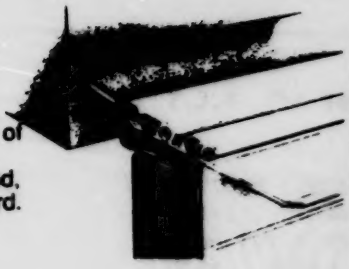
FLOOR SEAL

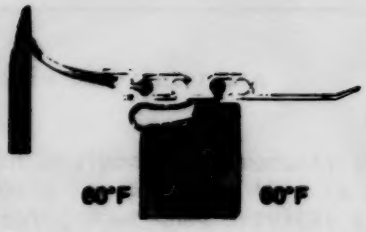
The floor seal consists of tubular EPDM rubber which molds to minor irregularities in the floor.

FIGURE 2.11: ASTRAGALS (BOTTOM SEALS)

TOP SEAL

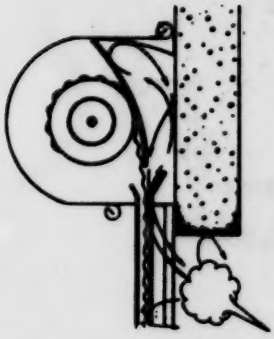
Differences in temperature between the inside and outside of a well-insulated door cause the door to bend, either inward or outward.

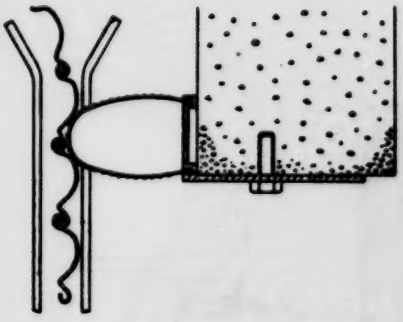


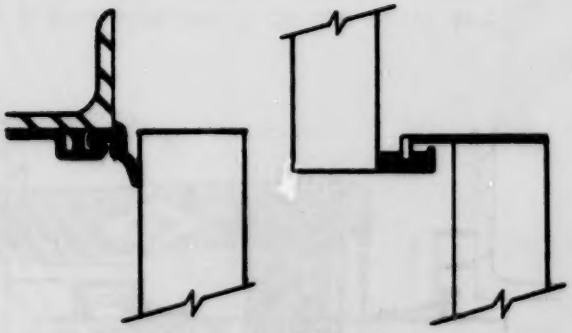


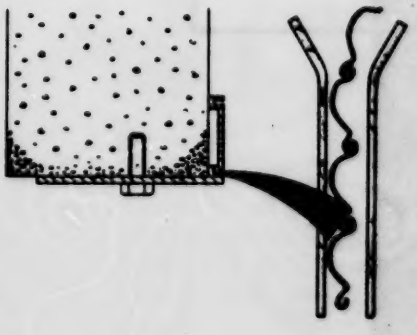
Door in normal position. The temperature on the outside and inside of the door is about the same.

The temperature on the outside of the door is considerably higher than on the inside. The door curves outward. The design of the top seal and the track channel allows this movement to take place without the door section or the top seal jamming against the header.









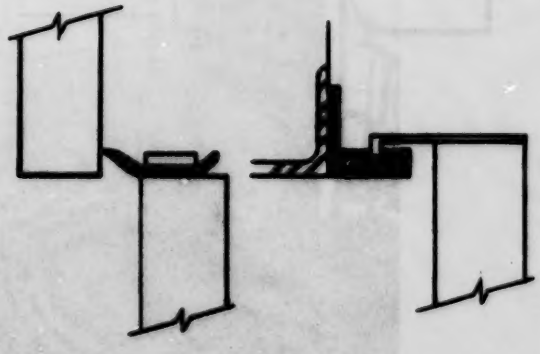


FIGURE 2.12: TOP OR HEADER SEALS

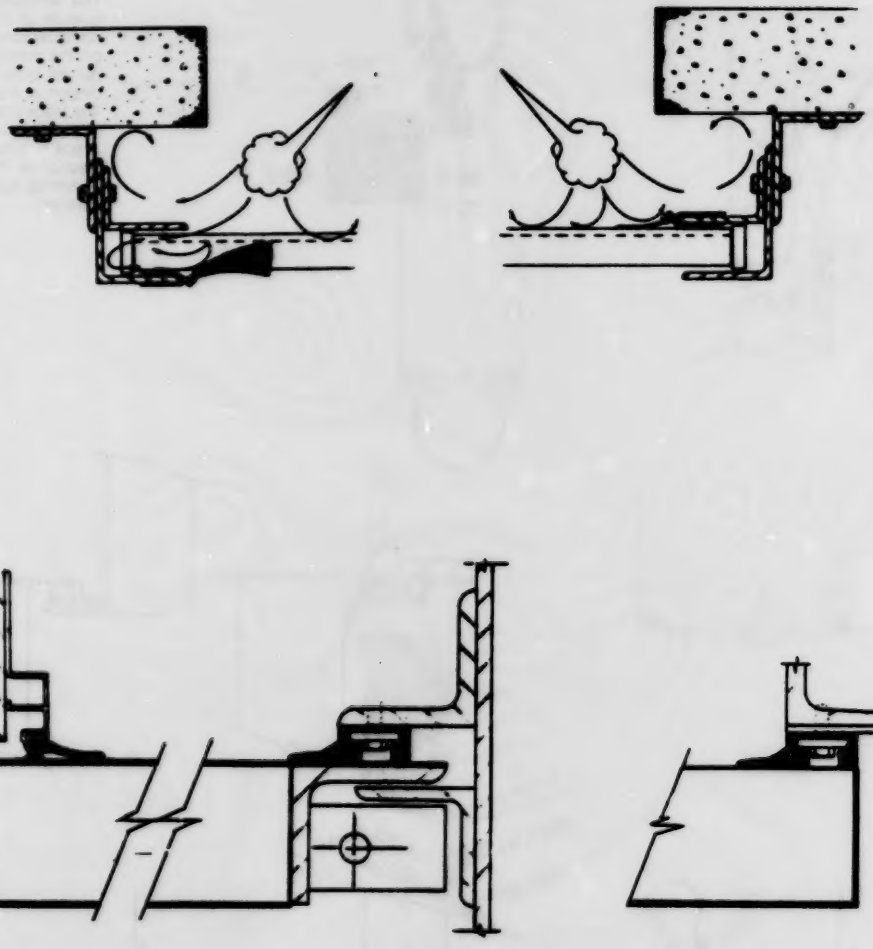


FIGURE 2.13: SIDE SEALS

2.3.4 The Vehicle-Door Interface

Various items of equipment or products are used to better accommodate the vehicle; this is particularly true for a shipping door that services a loading dock. Among the items in use are the following:

(i) Dock levellers: To facilitate loading or unloading, a device is required to bridge the difference in level between the floor of the truck and that of the building. A dock leveller with hydraulic or spring-adjusted ramps performs this function.

(ii) Dock bumpers: The loading dock is a relatively high-risk area, and to minimize or avoid damage to the building or the door, dock bumpers and other protective devices are often used.

(iii) Trailer Seals: Trailer seals (Figure 2.14) are made of a compressible foam and are usually placed externally on the sides and

FIGURE 2.14: TRAILER SEALS

the top of a loading dock. Some manufacturers offer a full seal including a seal for the bottom. When a trailer is backed up to the dock, an air seal is formed by compressing the foam.

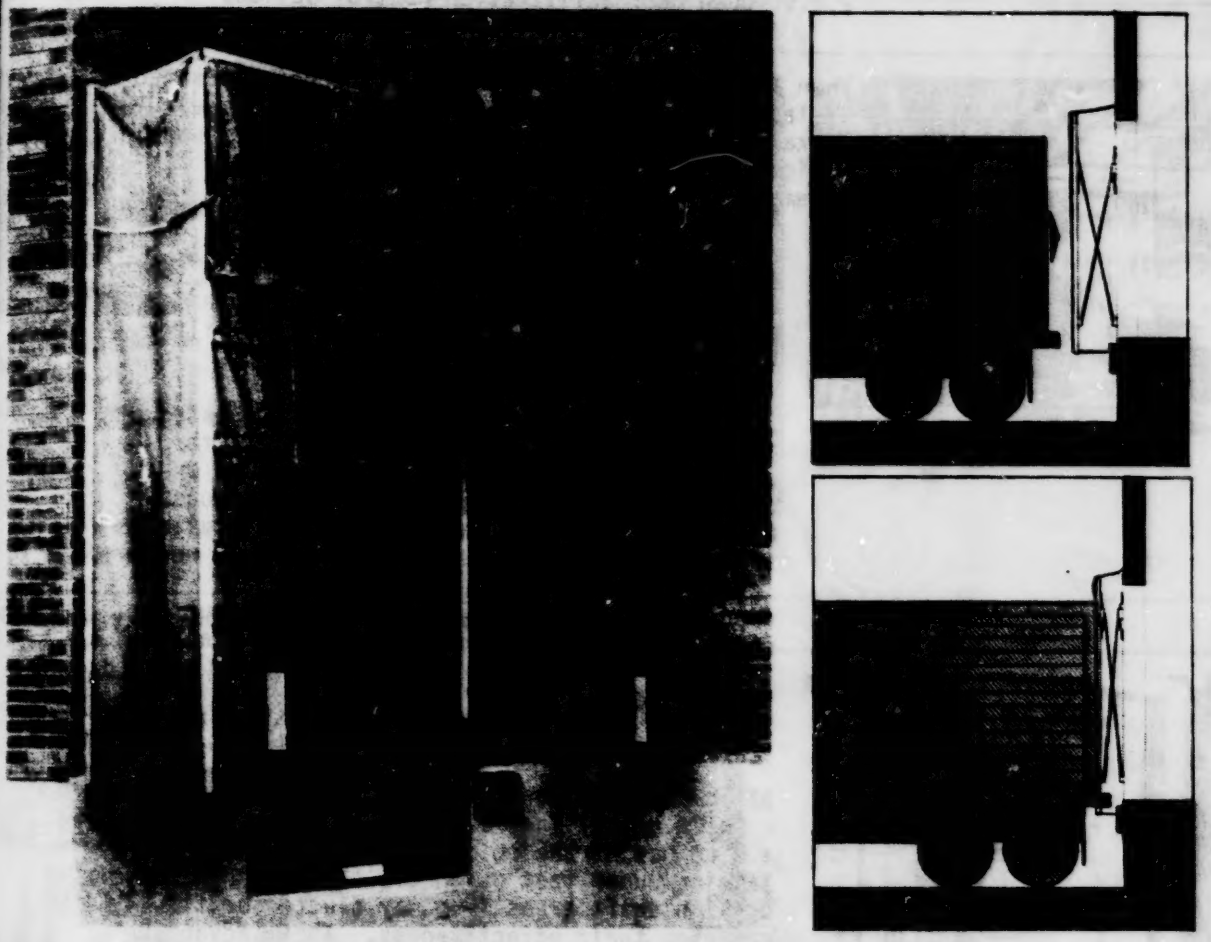
Trailer seals reduce infiltration. As well as keeping cold (or warm) air out, they also exclude rain, snow, dust and dirt.

Trailer seals also make it harder to pilfer merchandise (tossed out between the door and trailer for later recovery).

The seals typically are made of high-density polyurethane foam held in place by vinyl-coated nylon and attached to galvanized steel pans or two-inch, kiln-dried wood frames. Most seals are designed to fit a doorway up to 8½ ft. wide by 10 ft. tall. Some come with adjustable head pads or adjustable flaps to custom-fit the seal to each trailer. Also, for high traffic doors, heavy duty flaps can be added to the pad surface to reduce abrasive wear.

(iv) Dock Shelters: These serve the same purpose as trailer seals; however, their construction is quite different. They consist of a heavy fabric supported by a metal frame that is usually sprung to provide a contact seal against the trailer (Figure 2.15). Units are available with translucent panels to provide working light during the day. Shelters are the only option for rail cars. Because the railcar cannot be moved to develop a positive seal, the shelter must be able to extend out from the dock and abut the rail car. The shelters come in a three or four-sided version.

(v) Dock Lights: Dock lights illuminate the interior of the truck or trailer box while loading or unloading. The lights are usually attached to a boom which allows them to be moved into position or just out of the way.



This unit is designed to retract upon impact. Its collapsable scissor arms are spring loaded keeping the shelter in a projected position. When compressed by an incoming truck the panels create a weather tight seal. The shelter can be used where truck heights vary, where oversized door openings must be reduced to suit the truck opening and where clear openings for material handling equipment are necessary.

FIGURE 2.15: DOCK (OR TRUCK) SHELTER

2.3.5 Open Door Infiltration Control Devices

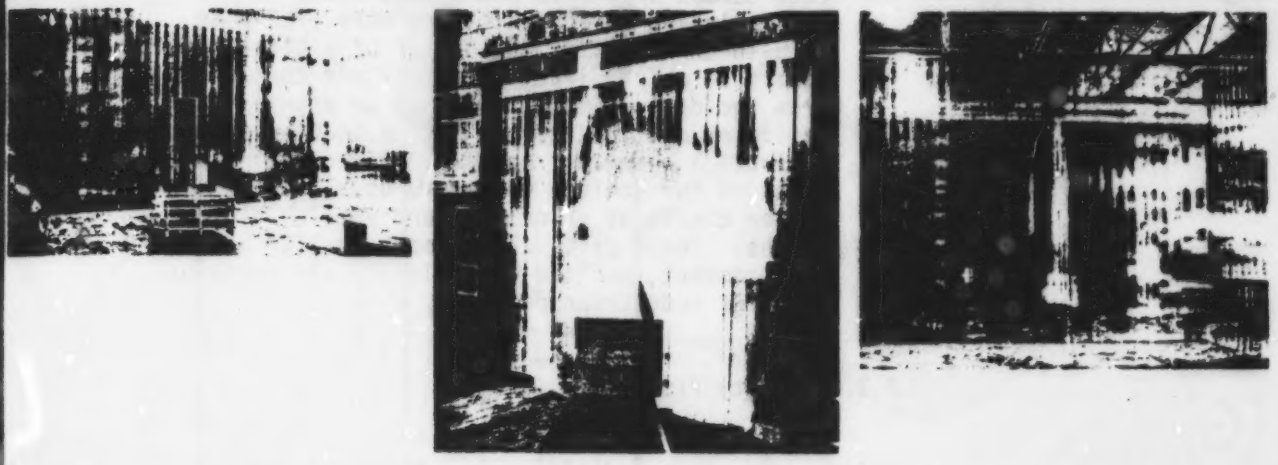
When the shipping door is open, the opening created is large and accordingly is a major source of air leakage (infiltration or exfiltration). Various devices are available to reduce or control the air movement that occurs when the door is open.

(i) Strip Curtains: Curtains composed of overlapping vertical strips are hung from the lintel or the wall about the door (Figure 2.16). They can be clear or tinted to filter light.

Strip curtains are often used between heated and unheated areas of a building (i.e., to separate conditioned and non-conditioned spaces). For a shipping door in continuous use, a plastic strip curtain can be installed if seals or shelters cannot be used. It need not interfere with the door's operation: the door may be opened and closed with the curtain hanging in place. Plastic curtains are also installed to supplement dock shelters or trailer seals.

Strip curtains do not provide the protection of a solid door. They are mounted with about a 2 cm gap at the bottom to prevent them from jamming under feet or wheels. Also, in windy or high draft areas they may flutter or flap, reducing their effectiveness. Their advantage is that they open only as much as is required, and they close automatically as soon as the vehicle or person passes through. Besides enhanced thermal performance, there are other benefits: increased safety with increased visibility through the clear plastic, sound reduction and exclusion of dust, dirt, fumes, insects and even birds.

Saves energy by separating heated and non-heated areas!



Saves energy at coldroom and freezer openings!

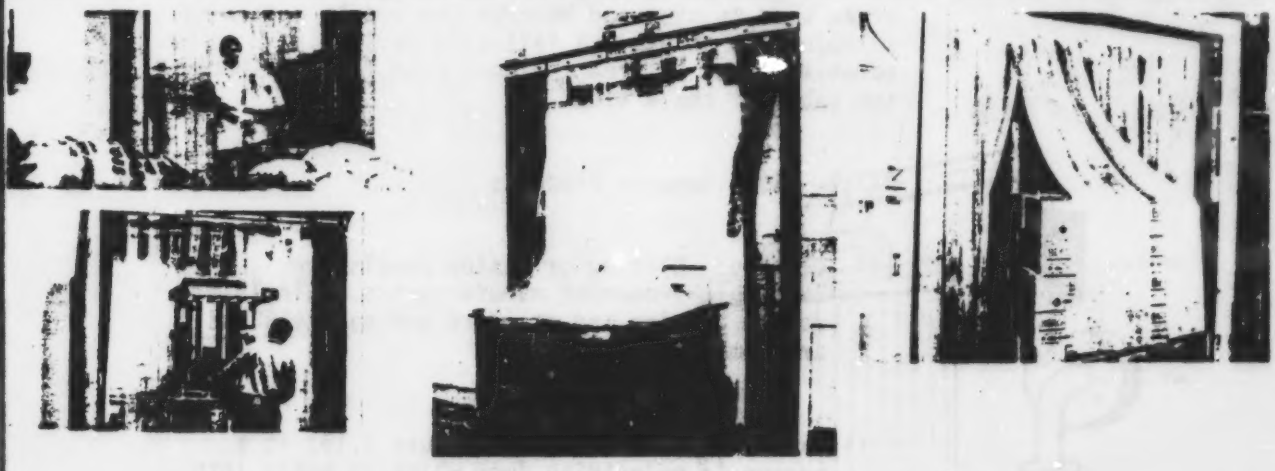


FIGURE 2.16: STRIP CURTAINS

(ii) Air Curtain: There are two main types of air curtains: recirculating and non-recirculating (Figure 2.17). Recirculating air curtains are most common in public buildings. Non-recirculating air curtains are more likely to be used in WLIBs. They consist of a blower and nozzle(s) which directs a jet of air downward from the door lintel. They may be mounted inside or outside and may have a heating unit to provide perimeter heating. Air curtains intended for vehicle entrances usually have higher discharge velocities and smaller slot widths. These units can be made smaller and more compact than the low-velocity air curtains used for pedestrian passages.

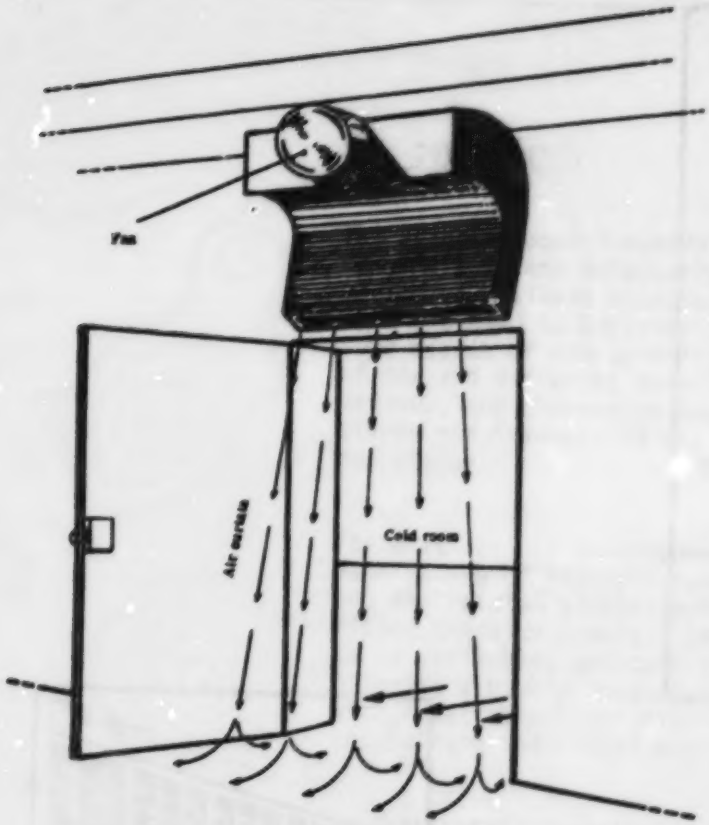
2.3.6 Safety Products

Safety products are designed to prevent accidental injury from both moving and stationary parts of the loading dock. Many safety features are directed at the automated operation of the shipping door. A combination astragal-safety edge (Figure 2.18) is often used to stop and reverse the door's motion if an object is struck. A fail-safe device is sometimes used to stop the door from falling should the cable or chain break.

2.3.7 Miscellaneous Products

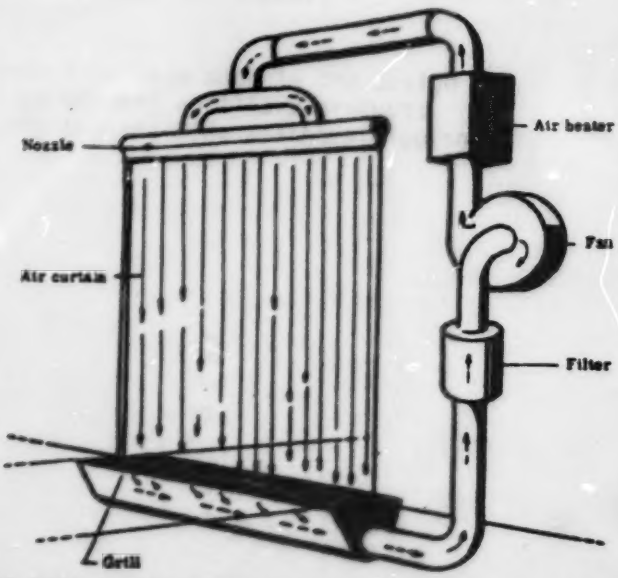
(i) Glazing: Glazing or vision panels are available from most manufacturers. Single or double glazing and standard and safety glass are some of the options.

(ii) Pass Door: A pass door (Figure 2.19) is a person or pedestrian door which is built into (i.e., as part of) the shipping door. When the shipping door is closed, the pass-door may be used for pedestrian access so that the shipping door may remain closed. Pass doors are usually restricted to large shipping doors.

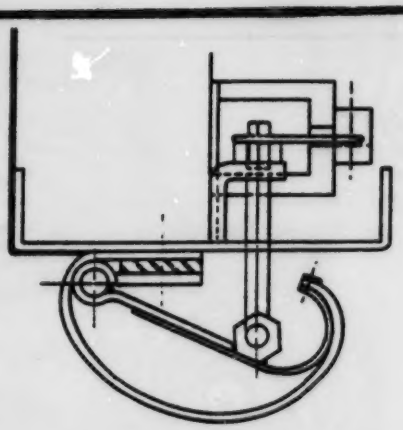


a) NON - RECIRCULATING

FIGURE 2.17:
AIR CURTAINS



b) RECIRCULATING



ELECTRO-MECHANIC SAFETY WEATHER STRIP

As an added safety feature for the protection of personnel and vehicles, the bottom edge of electrically operated vertical lift doors may be fitted with an electro-mechanic safety weather strip.

FIGURE 2.18: A SAFETY FEATURE

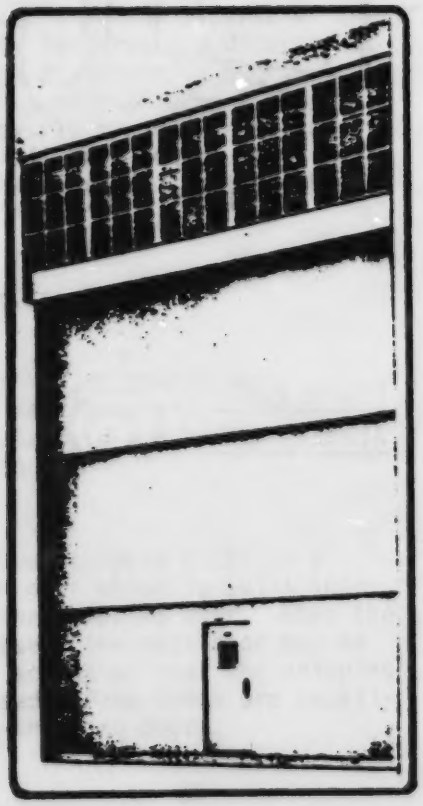


FIGURE 2.19: A PASS DOOR IN A LARGE VERTICAL LIFT DOOR

2.4 DEVELOPMENTS

The shipping door industry appears to be undergoing considerable and relatively rapid change. In a period of business slowdown, the industry is faced with the need to build better doors. The need for some degree of energy efficiency, the availability of new and different materials, novel control devices, and changes in the way goods are moved, stored and inventoried are some of the forces making for change.

The most obvious development has been the manufacture of highly insulated doors (Figure 2.20) and the related technology of composite, insulation-filled sandwich panels. Sales figures do not appear to be available, but most companies seem to be offering a highly insulated, relatively tight door with relatively sophisticated methods of stiffening and joining individual door panels.

Another notable development has been the quick acting door, i.e., with fast and controlled opening and closing. This acknowledges the important role that the open door plays in space conditioning costs over both the winter and summer.

Improvements have been made in the design and availability of many ancillary products, particularly top and side weatherstripping.

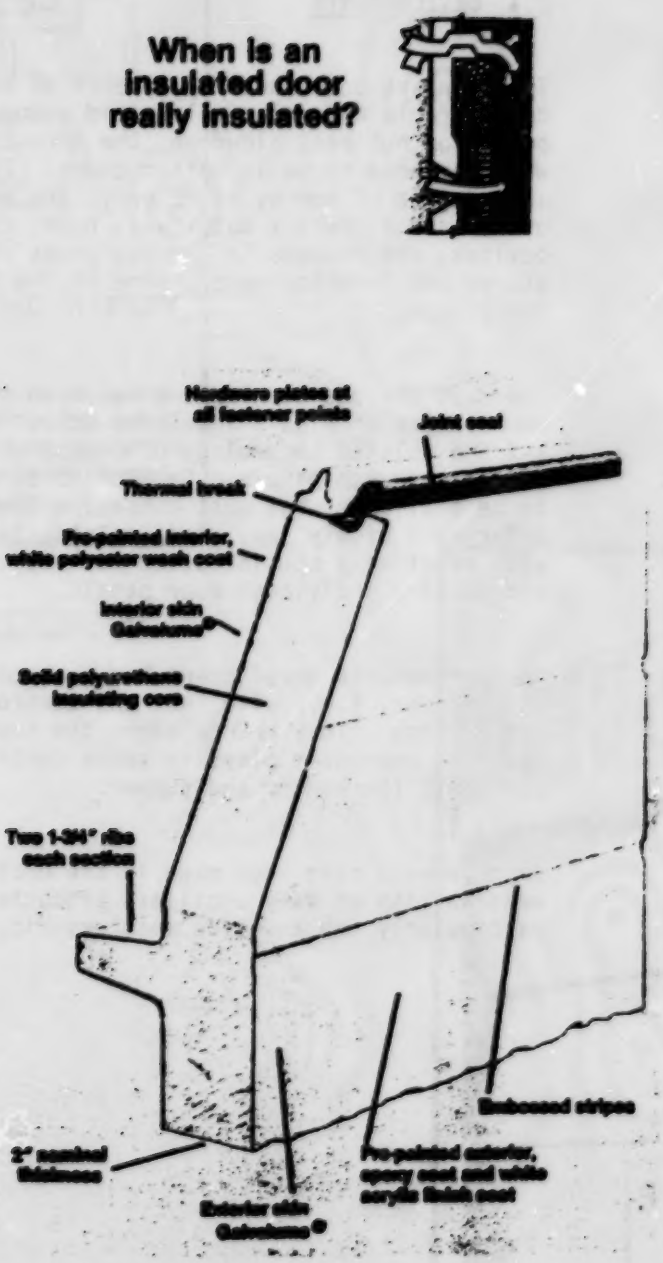

When is an insulated door really insulated?
Hardware plates at all fastener points
Joint seal
Thermal break
Pre-painted interior, white polyester wash coat
Interior skin Galvalume®
Solid polyurethane insulating core
Two 1-3/4" ribs each section
Embossed stripes
2" nominal thickness
Pre-painted exterior, epoxy coat and white acrylic finish coat
Exterior skin Galvalume®

FIGURE 2.20: A HIGHLY INSULATED DOOR PANEL

3. SURVEY OF SHIPPING DOOR INSTALLATIONS

3.1 INTRODUCTION

Product literature and marketing brochures do provide some idea of the nature and scale of the current service-door industry. This information is probably more indicative of the potential market than of previous practice. Nor do sales brochures provide many clues as to the nature of shipping doors in the existing stock of buildings. As energy conservation is an issue that concerns both existing facilities as well as future buildings, some indication of the existing stock of door installations was needed. Additional reasons for conducting a door survey were:

- to obtain information about the condition of installed doors
- to gain some idea as to which energy-related products are being used in practice, and, thereby, to assess the impact of energy prices as far as service doors in WLIBs are concerned.

The survey was intentionally a limited one. Funding was only one, and not necessarily the main, constraint. It was thought that a comprehensive (Canada-wide, statistically structured and detailed) survey was not warranted. Accordingly, this survey was conducted by one person, using a standardized procedure. It encompassed a somewhat biased sample of buildings in Ontario.

To avoid the delay and red tape involved in actually gaining entry to a building, the survey was limited to exterior inspection. This, of course, limited the data gathered to what could be seen from the outside. A number of features such as actuation devices, insulation, interior dock lighting, some weatherstripping and air curtains, cannot be seen when doors are closed.

TABLE 3.1: TYPES OF SHIPPING DOOR

ITEM \ DOOR TYPE	ROLLING		FLUSH SECTIONAL OVERHEAD		PANEL SECTIONAL OVERHEAD		VERTICAL LIFT		SWINGING		SLIDING		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
INCIDENCE	35	11.0	53	16.7	214	67.3	4*	1.3	4	1.3	8*	2.5	318	100
MATERIAL														
WOOD	0	-	35	11.0	211	66.4	0	-	3	1.0	8	2.5	257	80.8
ALUMINUM	17	5.4	0	-	0	-	0	-	0	-	0	-	17	5.4
STEEL	18	5.7	2	.6	3	1.0	4	1.3	1	0.3	0	-	28	8.8
FIBREGLASS	0	-	16	5.0	0	-	0	-	0	-	0	-	16	5.0
WINDOWS	0	-	23	43	67+	31	4	100	1+	25	0	-	95+	30.0
DOCK FLOOR														
• ABOVE GRADE	22	63	50	94	163	76	0	-	2	50	0	-	237	75
• AT GRADE	13	37	3	6	43	20	4	100	1	25	6	75	70	22
• BELOW GRADE	0	-	0	-	8	4	0	-	1	25	2	25	11	3
DOCK LEVELLER	2	6	17	32	72	34	0	-	1	25	2	25	94	30

* ALL IN ONE BUILDING

\+ ONE WITH DOUBLE-GLAZED WINDOWS - A TOTAL OF TWO BUILDINGS WITH DOUBLE GLAZING

3.2 SURVEY METHOD

Based on the product information gathered and a few trial inspections, a survey form was drawn up. This form is attached and a completed version is included in Appendix B.

Some 39 buildings and 318 doors were surveyed. A subjective attempt was made to obtain a spectrum of installations. Particular industrial sub-divisions were systematically looked at, and buildings in the London, Ottawa, Burlington, Brockville and Kitchener-Waterloo areas were included in the survey. A total of 85 different sets of door installations were surveyed. The number of doors in each building ranged from 1 to 33; the average number of doors was 8.2 per building, with some two or three different types of shipping door in each building.

As a computational aid, the computer program SASS (Statistics Applications for the Social Sciences) was used. A record of the data and analytical output is provided in Appendix C.

Before the results are discussed a word of caution is needed: this survey is representational, not authoritative. The survey results are useful, but they should neither be given too much weight nor used out of context.

3.3 SURVEY RESULTS

A summary of the survey of door installations is provided in Tables 3.1 and 3.2. A discussion of the findings follows.

3.3.1 Incidence of Door Type:

Some 84 per cent of the in-place doors are sectional overhead doors. Of these, 80 per cent are of wood single-panel construction, and 20 per cent are of wood flush construction. Clearly, the primary focus for any concerted attempt at thermal retrofit must be the wood sectional overhead door. About 11 per cent of the doors surveyed are rolling doors;

TABLE 3.2: SHIPPING DOOR FEATURES

ITEM/ ATTRIBUTE	ROLLING		FLUSH SECTIONAL OVERHEAD		PANEL SECTIONAL OVERHEAD		VERTICAL LIFT		SWINGING		SLIDING		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
INCIDENCE	35	11.0	53	16.7	214	67.3	4	1.3	4	1.3	8	2.5	318	100
HEADER SEAL	0	-	17	32	52	24	0	-	0	-	6	75	75	24
SIDE SEALS	17	49	17	32	57	27	0	-	0	-	6	75	97	31
ASTRAGAL	21	60	52	98	205	96	4	100	2	50	6	75	290	91
TRAILER SEAL	0	-	48	91	37	17	0	-	0	-	0	-	85	27
DOCK SHELTER	2	6	0	-	9	4	0	-	0	-	0	-	11	3
TESTABLE*	19	54	20	38	120	56	0	-	0	-	4	50	163	51

* FOR AIR LEAKAGE CHARACTERISTICS (WHEN DOOR IS CLOSED)

as would be expected these are metal, about equally divided between steel and aluminum construction. Vertical lift doors and swing doors are relatively uncommon, and only two to three per cent of the doors are wood sliding doors. Note that in each case all the sliding doors and all the vertical lift doors occur in a single building.

Gabry [1] reported that 67 per cent of all the overhead doors being sold in the U.S. by 1979 were made of steel; some 42 per cent of these were insulated, and the wood-panel door was becoming extinct in commercial and industrial applications. This situation may or may not prevail in Canada but, based on the survey findings, there is little evidence of this great a change in the nature of the stock of shipping doors. It would appear that the wooden sectional overhead door has been and, perhaps still is, the low capital-cost staple of the shipping door industry.

3.3.2 Materials

Wood doors are clearly the most common (81 per cent), followed by steel at 9 per cent, with fibreglass (flush sectional overhead) and aluminum (rolling doors) each making up about 5 per cent of the sample.

3.3.3 Thermal Insulation

Because the survey was only an external survey it was, in many instances, difficult to establish whether the door was insulated or not, either when installed or as a retrofit. Of the 318 doors surveyed some 16 seemed to be insulated, and these were flush sectional overhead doors all in the same building.

It is unlikely that any of the wood panel sectional overhead doors have any insulation. Even to retrofit a door of this type is difficult. Similarly, unless in a very new facility, it is highly unlikely that any of the rolling doors in the survey is insulated. From observations of the presence or absence of weatherstripping and the

level of maintenance, it is considered that probably less than 10 per cent of the doors surveyed are insulated in any way.

3.3.4 Air Leakage or Infiltration Considerations

Survey results concerning those attributes that affect the air leakage characteristics of the door (both closed and open) are summarized in Table 3.2.

Most (some 91 per cent) doors have an astragal or bottom weatherstripping. There are header seals (top weatherstripping) on only 24 per cent of all doors or 26 per cent of those doors with an astragal. All doors with header seals have both side seals and an astragal, and therefore 24 per cent of all doors are weatherstripped on all four sides. Similarly, one-quarter of all the panel sectional overhead doors have weatherstripping on all four sides of the door.

It is interesting to note that only 60 per cent of the rolling doors were observed to have astragals, and none appeared to have top weatherstripping (because of the hood it was difficult to tell). None of the rolling doors surveyed is equipped with trailer seals, in spite of the fact that 63 per cent (see Table 3.1) of these doors serve above-grade shipping docks, i.e., the truck and trailer do not drive through the door to unload.

Because of the nature of the survey it was difficult to gather reliable information on seals between door sections. It is unlikely, however, that many (if any) of the sectional overhead or rolling doors have any form of seal or weatherstrip across slats or panels. This is not a significant issue insofar as energy conservation is concerned.

It would seem that with flush sectional doors an effort is made to reduce air infiltration, especially when the door is in service, as 91 per cent have trailer seals. Conversely, less than 20 per cent of wood-panel sectional overhead doors are provided with trailer seals.

There are 11 dock shelters on three buildings in the survey.

A test facility and procedure have been developed by BEG to evaluate the air leakage characteristics of a closed shipping door. About half of the doors in the survey are suitable for testing because the size, shape and nature of their door frames are compatable with the test facility.

3.3.5 Door System

Having looked at the properties of the door itself and the door frame interface, some attention should be paid to the nature of the door system. For example, consider the nominal size of the door. Detailed information is provided in Tables C9 and C10 in Appendix C; it is worth noting here that:

- some 70 per cent of the doors surveyed are in the 8', 10' and 12'* height range. 21 flush sectional doors are relatively small (6' x 6' doors), and the four vertical lift doors are all 16' in height.

- some 53 per cent of the doors are 8' in width, another 22 per cent 10' and about 8 per cent of the doors are 6' or 12' wide.

- the largest doors surveyed are two rolling doors, each 22' wide and 16' high.

Windows are a feature of many doors. They can constitute a large area of low thermal resistance, and their perimeter seals can be a source of leakage. Of the doors surveyed, only 30 per cent have windows and of these only two doors have double- glazed windows.

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* All the doors in these buildings were bought and installed on the basis of Imperial sizes, and there is little point in converting these nominal sizes to the equivalent S.I. unit.

In general, large vertical lift doors are installed in order to accommodate the passage of trucks into and out of the building. The finished grade and floor slab at the door must therefore be at the same level. However, an above-grade dock and external loading/unloading are much more common; 75 per cent of the doors surveyed service a shipping dock. Figure 3.1 and Table 3.1 show that twenty-two per cent of the doors are on-grade and three per cent (11 doors) use a ramped or below-grade system.

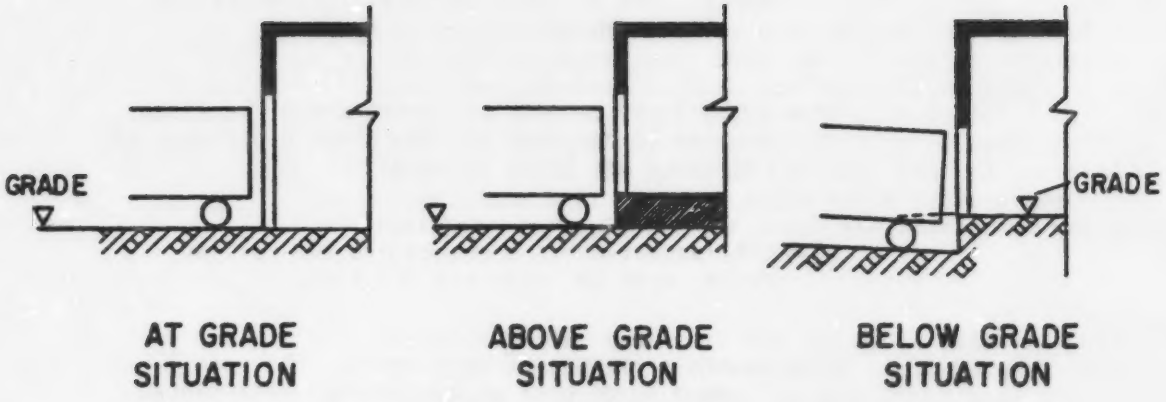

FIGURE 3.1: VARIOUS LOADING ALTERNATIVES

About one third of all door systems employ a dock leveller. As 70 doors are on-grade systems, the proportion of doors with loading docks with dock levellers is 38 per cent (i.e., [94 / (237 + 11)]).

3.3.6 Door Condition

A somewhat subjective ten-point scale was applied to the observed condition of each door. A score of ten represents the best condition for that particular type and construction of door, e.g., a new door. At the other end of the scale a score of one indicates a badly damaged or deteriorated door that can no longer effectively separate the interior and exterior environments (when closed). That is, it is broken, non-operative or locked shut to ensure security. Between these limits, the score was determined by individual judgement of the condition of the door and all its ancillary fittings, giving due consideration to each component, and thereby evaluating the overall condition of the shipping door. For example, the door shown in Figure 3.2 has been rated 6, not necessarily on account of the repair work but largely because of the general state of repair.

In general, the door itself was given most consideration. For example, Figure 3.3 and 3.4 show two sectional overhead shipping doors with trailer seals that have taken considerable abuse. In this case the steel door (Figure 3.3) is actually in better condition than the wooden door, even though the trailer seals on the steel door make it appear worse. The overriding factor here is the gaps between the door and its frame. The steel door has a much tighter fit.

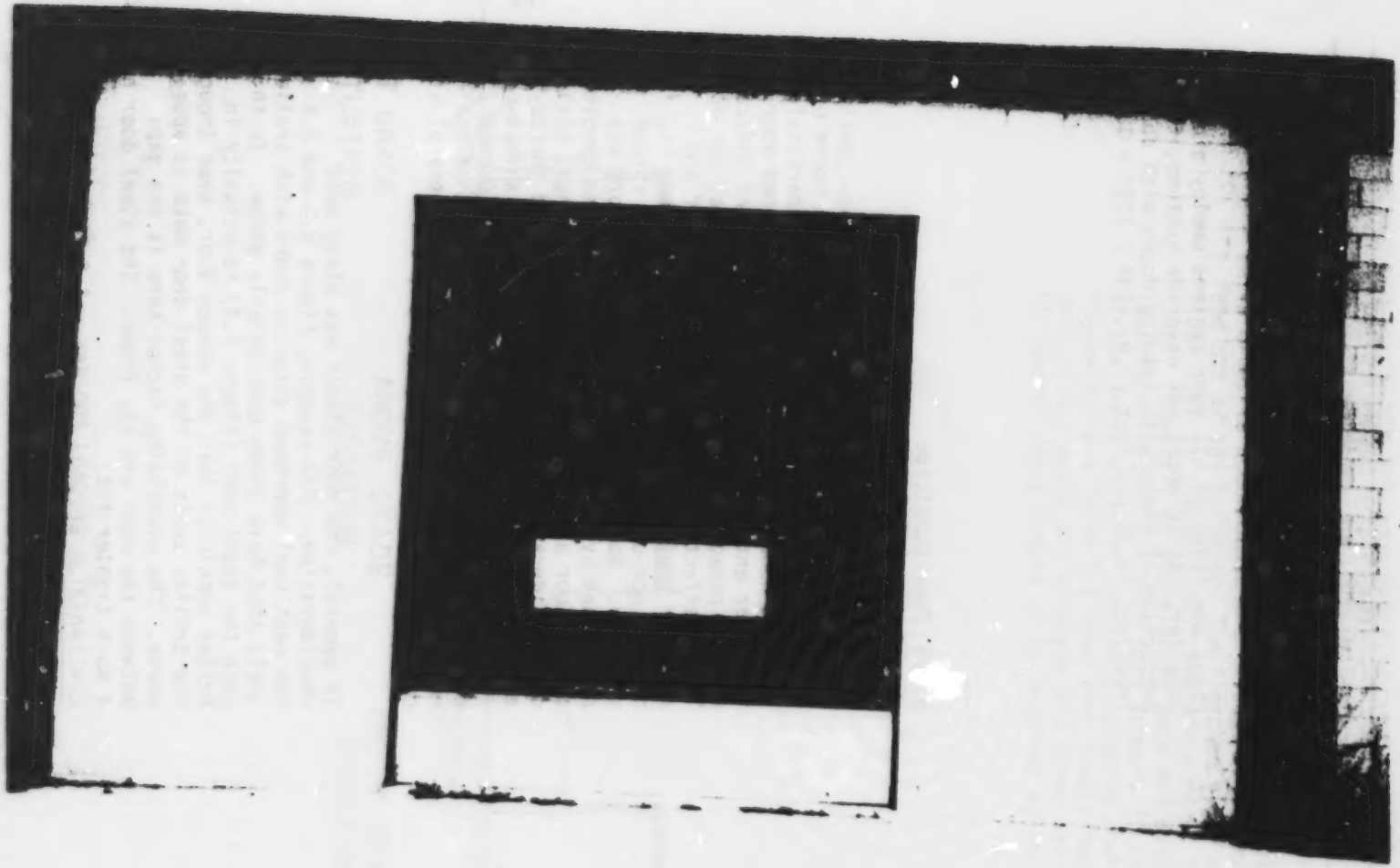

FIGURE 3.2: A SHIPPING DOOR - RATED 6

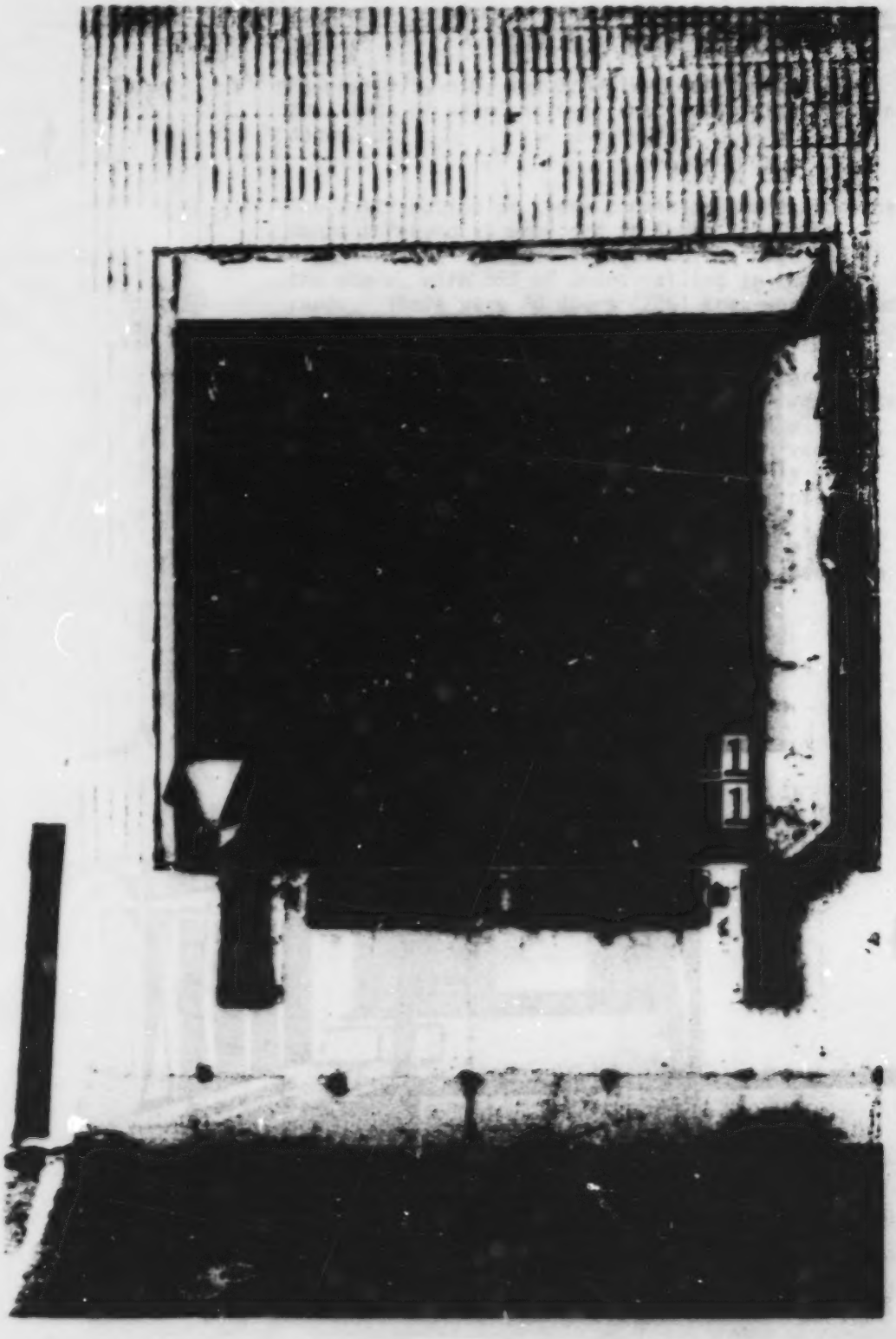

FIGURE 3.3: A SECTIONAL OVERHEAD STEEL FLUSH SHIPPING DOOR

FIGURE 3.4: A SECTIONAL OVERHEAD WOODEN PANEL SHIPPING DOOR

Figures 3.5, 3.6, and 3.7 give some indication of the kinds of wear and tear that occur with shipping doors.

The distribution of these condition scores for the doors surveyed is provided in Table 3.3. The distribution is skewed towards to the high end of the scale, with 39% of doors falling in the 7-8 range. There were 70 doors (22%) that were judged to be new or nearly new. At the bottom of the scale, 47 doors were given a score of one, but it should be noted that all of these doors were observed in three shipping and receiving warehouses operated by trucking companies. In general then, the vast majority of shipping doors observed were rated as 5 or more on the scale. That may be attributed to lack of use or some degree of maintenance. Doors in continual use (e.g., at trucking companies) do not appear to be well maintained, presumably because they are open much of the time.

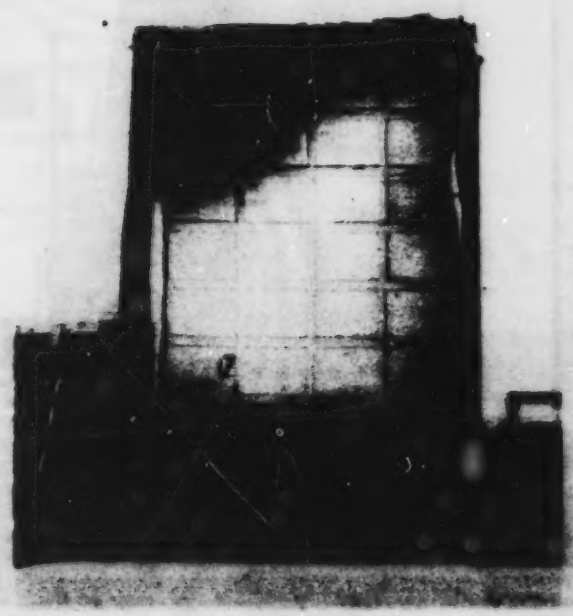

FIGURE 3.5: A WORN DOCK SHELTER

FIGURE 3.6: CONCRETE BLOCK INFILL, RUDIMENTARY SIDE SEALS AND REPAIR WORK

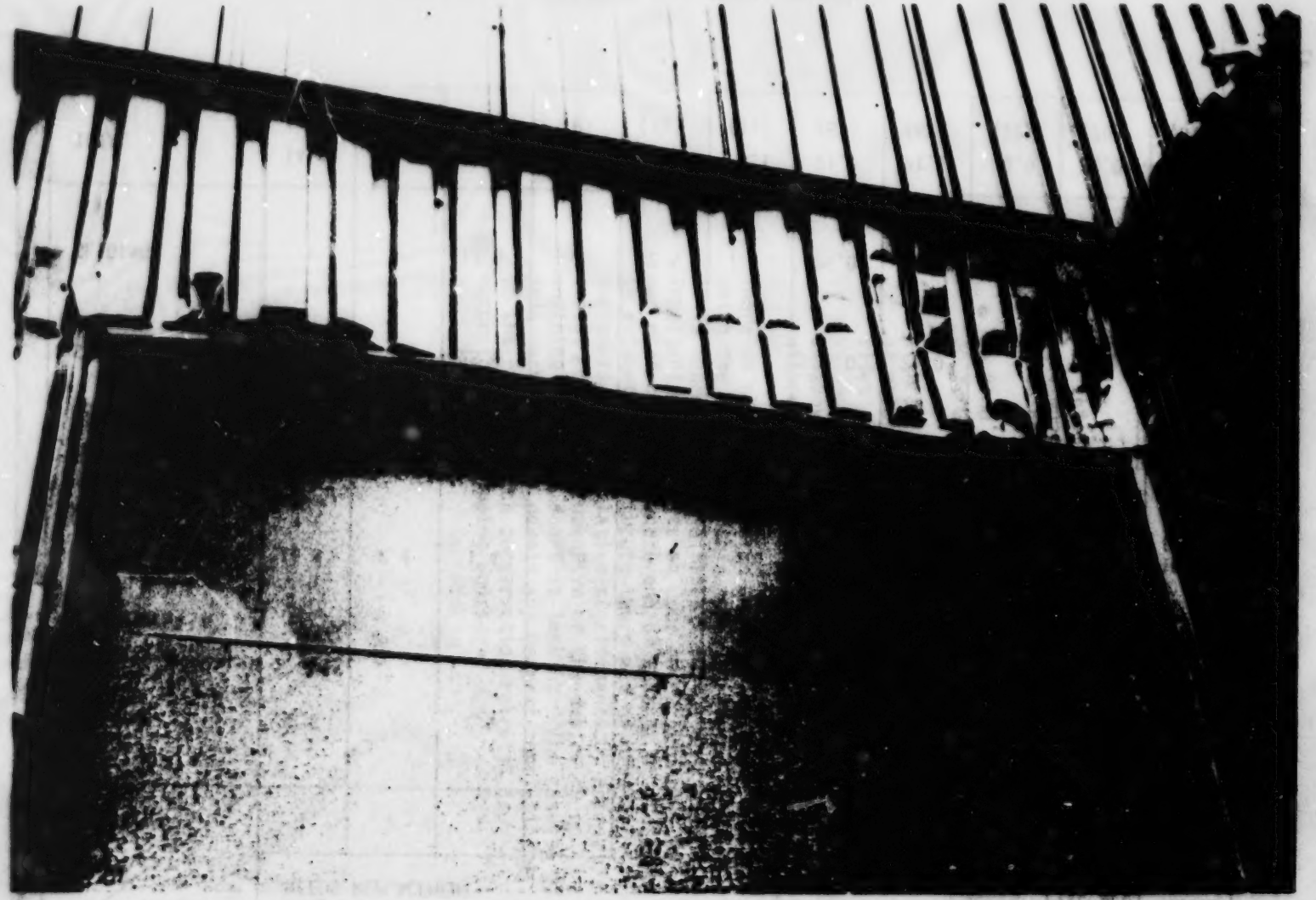

FIGURE 3.7: WEAR AND TEAR

RATING / DOOR TYPE	POOR ← NEEDS REPLACEMENT 1	2	3	4	5	6	7	8	9	EXCELLENT → LIKE NEW 10	TOTAL
ROLLING	28.6	-	2.9	-	8.6	-	22.9	28.6	8.6	-	100.2% (35)
FLUSH SECTIONAL OVERHEAD	-	-	-	-	-	1.9	15.1	1.9	1.9	79.3	100.1% (53)
PANEL SECTIONAL OVERHEAD	16.9	2.4	1.4	3.8	3.3	5.6	23.4	24.8	5.6	13.1	100.3% (214)
VERTICAL LIFT	-	-	-	-	-	-	-	-	100.0	-	100% (4)
SWINGING	25.0	-	25.0	-	-	-	25.0	25.0	-	-	100% (4)
SLIDING	-	-	12.5	-	12.5	-	25.0	25.0	25.0	-	100% (8)
TOTAL	14.8 (47)	1.6 (5)	1.9 (6)	2.5 (8)	3.5 (11)	4.1 (13)	21.7 (69)	21.1 (67)	6.9 (22)	22.0 (70)	100.0% (318)

TABLE 3.3: RESULTS OF DOOR CONDITION SURVEY

3.4 CONCLUSIONS

Based on this limited but nonetheless useful survey, a typical door in the existing stock of WLIBs could be said to be:

- an 8'-0 x 8'-0 wood panel sectional overhead door, uninsulated in any way
- with an astragal to avoid or control the entry of cold air, dust, dirt and moisture (but the sides and top are not sealed), and
- an above-grade loading dock (but probably without trailer seals or dock leveller).

There do not appear to be any similar surveys with which the results of this survey could be compared. It is therefore very difficult for us to assess the impact of energy costs on door installations. From our contacts with owners and/or tenants of WLIBs it is evident that, although there may be greater awareness of the relative significance of energy costs, either the incentive or the desire to do anything about the doors is lacking. The results of this survey do not permit any general conclusion as to the rate at which conservation retrofit is occurring with shipping doors.

4. LITERATURE SURVEY

4.1 SEARCH

A comprehensive search of several computerized technical data bases plus a survey of the Engineering Index (going as far back as 1953) revealed that relatively few papers or articles have been published on the topic of shipping doors. It would appear that much of the R and D that is done (if in fact much is done) is proprietary and rarely published. A number of door companies were contacted, and several reports were made available. As BEG's work on shipping doors became known and after we had established contact with the Canadian Door Institute, we were provided with information that has been particularly useful. Some of this work warrants summarizing here.

4.2 ENERGY CONSERVATION CONSIDERATIONS

One of the more useful publications was written by Frank F. Gabry in March 1980 [1]. Although his figures apply to the U.S.A. and some of the economic aspects dealt with in the paper have changed, most of the points he makes are still valid.

He demonstrates that during one of the Chicago area's coldest winters, the transmission heat loss through an uninsulated door was about 7.5 times as much as that through an insulated door. This heat-loss difference translated to a fuel-cost saving of US $120, based on the prevailing utility rates at that time. He also showed that another US $150 could be saved by adding several basic sealing options to the insulated door.

Gabry points out that infiltration through the sectional overhead doors can undermine the effectiveness of the best-insulated doors. He states that pressurization tests of shipping doors have demonstrated that, for an average door installation, approximately 2.32 L/s (litres per second) of air will flow per metre of length (1.5 cfm per foot of length) of side openings and 1.16 L/s per metre of length (.75 cfm per ft length) of section joints - even when the wind is less than 6.67 m/s (15 mph). He estimates that for a 4.27 m

(14 by 14 ft) shipping door, the total infiltration rate amounts to 69 L/s (147 cfm). The heat loss associated with this infiltration rate amounts to 83 W/°C temperature difference.

For the insulated door the transmission losses amounted to about 12.5 W/°C temperature difference while for the uninsulated door the difference is about 92 W/°C of temperature. Gabry concludes that the heat loss due to infiltration can be just as substantial as that due to transmission through an uninsulated door. Gabry estimates that the payback for the additional expenses for door insulation and sealing is less than two years through savings in fuel costs.

Another particularly worthwhile contribution is a paper entitled "Industrial Infiltration" by Michael K. Kennon and published in the Proceedings of the Fourth Annual Industrial Energy Conservation Technology Conference [2]. In this paper the wider implications of infiltration and, in particular, the need for better computational models are addressed. A number of example doors are discussed, and there is a very useful discussion as to the placement of doors and their use. Although the paper is primarily directed at air curtains, Kennon makes a number of points:

- The "crack method" is in many applications grossly and obviously erroneous. For many industrial problems it simply is not relevant
- In four sample buildings, infiltration through open doors accounted for between 10 and 25 per cent of the total space heating load. These are not extreme cases; in a number of buildings infiltration through open doors account for 90 per cent of the space heating load
- Dock seals between the truck body and the door reduce infiltration by between 50 and 90 per cent
- Infiltration through a door is a complex problem that is affected by the building, its construction and its operation, as well as the external environment.

Assistance was also provided by Mr. Roger A. Kent who kindly sent us details [3] of a heat loss analysis procedure for doors that his company has been using, together with some details of a study conducted by Chalmers University of Technology for Nomafa A.B, a door manufacturing company located in Halmstad in Sweden. The thrust of this work is directed at speeding up the opening and closing times for doors, and the following points are made:

- Door costs have to be looked at as a whole, since not only is space-heating energy important but the cost of drivers and other personnel and the equipment involved must also be considered

- For a shipping door the greatest heat losses occur while the door is being opened, when it is open, and later when it is being closed.

Many publications, especially trade publications, contain information about shipping doors. Often the performance related information is unsubstantiated or unexplained. It is therefore difficult to use. This chapter is therefore concluded with an appeal: if and when test results (whether for experimental, certification or promotional purposes) or analytical results are reported, then an attempt should be made to provide all relevant information.

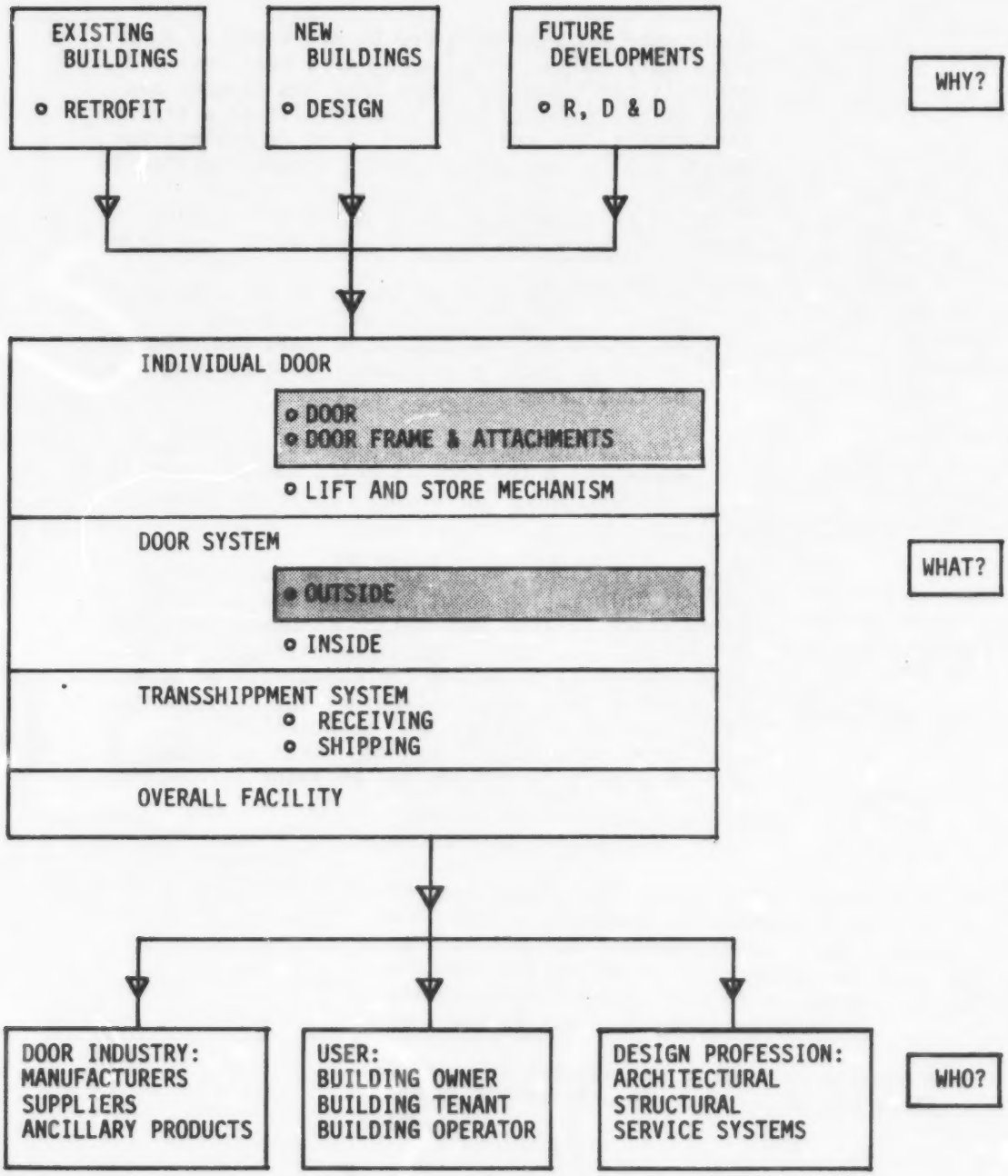

TABLE 5.1: FLOWCHART OF PERFORMANCE CONSIDERATIONS

* Only the hatched items are dealt with in any detail in this report.

5. PERFORMANCE CONSIDERATIONS

5.1 WHY, WHAT AND WHO

The rate at which the stock of warehouse and light industrial buildings (WLIBs) is renewed is 3 to 4 per cent per year [4], i.e., 96 to 97 per cent of next year's stock already exists. Given a mandate to effect and promote energy conservation in WLIBs, it follows that some emphasis must be placed on improving the energy-related performance of the existing stock of WLIBs and, hence, their shipping doors. Door systems in new facilities must also be addressed because the sooner energy-efficient door systems are widely implemented, the greater the cumulative impact at both the individual and national level. For the same reason there is a real need to encourage and sustain further developments: not only for the purposes of energy conservation but also for product and market preservation and expansion.

In Chapter 1 the point was made that a shipping door is merely a part of a larger system and, in Figure 1.1, the various levels at which the merits of energy conservation must be considered are identified. Given that there is a need to conserve energy, it follows that the door should not be considered in isolation, and any energy conservation strategy must acknowledge the appropriate economic context. In Table 5.1, an attempt is made to relate these generalized door considerations (What) with the three categories of need (Why) and the principal clients (Who) for any conservation strategy.

Figure 5.1 indicates that the shipping door problem is not necessarily simple and that there are likely to be numerous effective conservation strategies, depending upon the building, the time-frame and the client involved.

It is not the objective of this report to arrive at one or more energy conservation strategies for shipping doors. One objective, however, is to identify and define some of the problems and issues involved. Clearly, one issue has to do with quantification. For example, although there is a perceived need for conservation strategies in existing buildings and new buildings, this need has yet to be assessed in monetary terms. Even more basic is the need for the quantification of the relatively straightforward problem of door performance insofar as energy is concerned.

SITUATION	SPACE HEATING ENERGY-RELATED CONSIDERATIONS	SUPPLEMENTARY ENERGY-RELATED CONSIDERATIONS	OTHER CONSIDERATIONS
DOOR CLOSED	TRANSMISSION INFILTRATION EXFILTRATION		SECURITY
DOOR OPEN	INFILTRATION EXFILTRATION	NATURAL VENTILATION (SUMMER COOLING) COMFORT AIR QUALITY	DIRT/DUST
DOOR OPENING/ CLOSING	TRANSMISSION INFILTRATION EXFILTRATION	COMFORT AIR QUALITY OPERATION: - EQUIPMENT - PERSONNEL	SAFETY DIRT/DUST

TABLE 5.2: DOOR PERFORMANCE CONSIDERATIONS

5.2 PERFORMANCE OF THE DOOR

In reviewing the literature on shipping doors, it soon became evident that a variety of methods is used to compute the contribution of the various factors that affect the energy-related performance of doors. Most of these appear to be manual and overly simplistic calculation procedures. Nor does there appear to be any single procedure that has industry-wide acceptance. There is not much point in attempting to review these methods; suffice it to say that many of the procedures and the supporting trade literature seem to place undue emphasis on transmission heat loss.

Table 5.2 lists the various attributes that need to be considered when evaluating the energy-related performance of a specific shipping door. For any door there are three situations to be considered, namely, the closed door, the open door and the opening or closing door. Obviously some knowledge of the actual or likely operating schedule for the door is required, and the relative importance of these three situations, in terms of space heating costs, will clearly depend on this operating schedule.

For any door, transmission and air leakage heat loss are the major contributors to space heating, but there are several other energy-related considerations. For example, if a door is opened and closed many times during every working day to admit and let out fork lift trucks, the principal contributor to space heating costs might well be infiltration during the opening and closing of the door. In this case, the space heating energy costs may be less important than the loss of operator time and wasted fuel energy caused by the fork lift trucks being forced to wait while the door is manually opened and closed, perhaps by each driver. On the other hand, a design consideration may be summer cooling where the intelligent use of sets of open doors could provide or augment natural ventilation and thereby avoid air conditioning.

Table 5.2 also lists non-energy related considerations that might have some bearing on the operation or performance of the door, e.g.,

security, cleaning, etc. Tables 5.1 and 5.2 demonstrate the nature, scope and significance of the energy-related performance of service or shipping doors.

5.3 CONCLUDING COMMENTARY

Subject to certain limitations (e.g., the field survey was restricted to Ontario), this report constitutes a state-of-practice review of shipping doors. Although directed at warehouse and light industrial buildings, the findings have general relevance. Furthermore, this study appears to be the first of its kind.

From an energy standpoint, shipping doors are important in that:

- the annual heat energy lost through transmission and air leakage in particular is significant
- in existing facilities, shipping doors are amenable, both practically and economically, to some degree of thermal retrofit. Insulating and sealing products are available, and the payback on retrofit is relatively short
- in a new building, the intelligent location and selection of shipping doors can lead to significant annual and long-term benefits. These benefits are likely to be lower operating costs (less space heating energy) and improved productivity (improved comfort, no draughts, reduced cleaning, better security, etc.).
- operating procedures, i.e., opening and closing doors, can usually be improved, often without additional cost.

The above conclusions are neither novel nor unique; progressive building professionals, most door manufacturers and knowledgeable building operators are all aware of the qualitative importance of shipping doors. The principal need at this stage is for a means of quantification: a relatively accurate, widely acceptable, and universally applicable method of computing the cost-benefit trade-offs involved. Until a suitable energy

analysis procedure is available and in common use it is difficult to influence the decision making process.

In this study we have attempted to be both pragmatic and general. The shipping door is only one element in the design or operation of a facility, and energy is only one of the costs of doing business. Nonetheless, both shipping doors or doorsystems and door-related energy costs are significant. In conclusion, two points, both concerning air leakage, need to be made:

a) in developing an energy conservation strategy for existing facilities, attention must be paid to reducing shipping door air leakage. This can readily and economically be done by means of seals and operational improvements. In general, it clearly makes sense to insulate the shipping door to the same level of thermal resistance as the walls of the building. Conversely, in a building with uninsulated walls, there is little merit in insulating the door.

b) in developing a product line, door manufacturers and distributors should be aware of the relative importance of air leakage. Whereas an air-tight but uninsulated door might constitute a viable product, a leaky but highly insulated door does not. From an energy perspective, a viable product line should reflect the variable interrelationship between air leakage and thermal resistance.

REFERENCES

1. Gabry, Frank F. "Retarding Heat Flow Through Sectional Overhead Doors". Plant Engineering March 20, 1980. pp.111-114.

2. Kennon, Michael K. "Industrial Infiltration." Proceedings of the Fourth Annual Industrial Energy Conservation Conference, 1982. Volume 2, pp.876-887.

3. Kent, Roger A. - private communication.

4. Peat, Marwick and Partners. "Building Category Profile: A Preliminary Study of the Physical and Energy Consumption Characteristics of the Warehousing and Light Industrial Building Sector" A report prepared for the Building Engineering Group under contract to the BETT program of EMR, Canada. June 1982 46 p.

APPENDIX A

Manufacturers and Suppliers of Shipping Doors

Amstel Manufacturing
159 Milvan Drive
Weston, Ontario
M9L 1Z8

Bray-Dor Inc.
4925 rue de Sorel
Montreal, P.Q.
H4P1G3

Clark Door of Canada Ltd.
125 Gibson Drive
Markham, Ontario
L3R 3K7

Durus Industries Inc.
1225 Loudoun Road
Winnipeg, Manitoba
R3S 1A3

Dyrol Industries Ltd.
9644-192nd Street
Surrey, B.C.
V3T 4W2

Equal Door Products Ltd.
#6-3815 61st Avenue S.E.
Calgary, Alberta
T2C 1N9

Filuma Door Company Ltd.
133 Queen Street East
Mississauga, Ontario
L5G 1N1

General Door Industries
P.O. Box 3000,
Milliken, Ontario
L0H 1K0

Imperial Door Limited
43 Shaft Road
Rexdale, Ontario
M9W 4M3

Indoco Industrial Door Co. Ltd.
c/o Amstel Manufacturing
159 Milvan Drive
Weston, Ontario
M9L 1Z8

Ken Mar Doors Ltd.
P.O. Box 502
Richmond Blvd.
Napanee, Ontario
K7R 3M4

Kinnear Industries Corp. Ltd.
1040 Martin Grove Road
Unit 24
Rexdale, Ontario
M9W 4W4

Lynx Industries Inc.
175 Upper Edison
St. Lambert, P.Q.
J4R 2R3

McCullock Engineering
P.O. Box 455
Bolton, Ontario
L0P 1A0

Nieco Flexible Strip Doors
c/o Amstel Manufacturing
159 Milvan Drive
Weston, Ontario
M9L 1Z8

Overhead Door Company of Canada Ltd.
586 Third Line Road,
Oakville, Ontario
L6J 5A8

Portes Imperial Ltd.
2150 Hymus,
Dorval, P.Q.
H9P 1H8

Protective Door Industries
c/o Amstel Manufacturing
159 Milvan Drive
Weston, Ontario
M9L 1Z8

Richards - Wilcox of Canada Ltd.
2 Terrace Street
P.O. Box 5060
London, Ontario
N6A 4N4

Rollag Ltd.
1224 Dundas Street East
Mississauga, Ontario
L4Y 4A2

Scythes Inc.
128 Sterling Road,
Toronto, Ontario
M6R 2B7

Secord Manufacturing
Division of Fisher & Ludlow Inc.
20 Teal Avenue
Stoney Creek, Ontario
L8H 7K6

Serco Engineering
100-15 The East Mall
Toronto, Ontario
M8Z 5X2

Stanley Door Systems Ltd.
42 Queen Elizabeth Blvd.
Toronto, Ontario
M8Z 1M1

Steel-Craft Door Products Ltd.
14820 Yellowhead Trail
Edmonton, Alberta
T5A 0X1

Taylor Building Products
631 N First Street
West Branch, Michigan 48661

Toronto Door Systems (1982) Ltd.
P.O. Box 2216, Station "C"
Downsview, Ontario
M3W 2S9

Upward Garage Doors Ltd.
1094 Westport Cresent
Mississauga, Ontario
L5T 1G1

Vizro Industrial Sales Co. Ltd.
80 Barbados Blvd.
Unit #4
Scarborough, Ontario
M1J 1K9

Wilson Industrial Doors of Canada Ltd.
P.O. Box 392
Stettler, Alberta
T0C 2L0

APPENDIX B

Door Survey Form

BEG SHIPPING DOOR SURVEY

Bldg No. (doors)	Type	Mat'l	Seal	Door W		Condition Scale (B 2 3 4 5 6 7 8 9 G)
	SO	Wd	Astr	H		Comments:
		Alum	Side	Glaz W		
	VL	St	Head	H		
Testable Yes/No	Sl	FG	Sect	#		
Photo No.	Roll	Plast	Trail Seal		Dock Level	
Frame Width	Sw	Insul	Dock Shelt		Grade	

Bldg No. (doors)	Type	Mat'l	Seal	Door W		Condition Scale (B 2 3 4 5 6 7 8 9 G)
	SO	Wd	Astr	H		Comments:
		Alum	Side	Glaz W		
	VL	St	Head	H		
Testable Yes/No	Sl	FG	Sect	#		
Photo No.	Roll	Plast	Trail Seal		Dock Level	
Frame Width	Sw	Insul	Dock Shelt		Grade	

Bldg No. (doors)	Type	Mat'l	Seal	Door W		Condition Scale (B 2 3 4 5 6 7 8 9 G)
	SO	Wd	Astr	H		Comments:
		Alum	Side	Glaz W		
	VL	St	Head	H		
Testable Yes/No	Sl	FG	Sect	#		
Photo No.	Roll	Plast	Trail Seal		Dock Level	
Frame Width	Sw	Insul	Dock Shelt		Grade	

Codes: SO - Sectional Overhead
VL - Vertical Lift
Sl - Sliding
Roll - Rolling
Sw - Swinging

Wd - Wooden
Alum - Aluminum
St - Steel
FG - Fibre-glass
Plast - Plastic
Insul - Insulation

Astr - Astragal
Head - Header
Sect - Sectional
Trail Seal - Trailer Seals
Dock Shelt - Dock Shelters

Glaz - Glazing
- Number of Glazings
Dock Level - Dock Levelers
Grade - Grade Level
(ramped, at, above ↓ — ↑)

BEG SHIPPING DOOR SURVEY

Bldg No. (doors)	Type	Mat'l	Seal	Door W		Condition Scale (B 2 3 4 5 6 7 8 9 G)
	SO	Wd	Astr	H		Comments:
		Alum	Side	Glaz W		
	VL	St	Head	H		
Testable Yes/No	Sl	FG	Sect	#		
Photo No.	Roll	Plast	Trail Seal		Dock Level	
Frame Width	Sw	Insul	Dock Shelt		Grade	

Bldg No. 3 (4 doors)	Type	Mat'l	Seal	Door W 120"		Condition Scale (B 2 3 4 (5) 6 7 8 9 G)
Phillip St.	(SO)	(Wd)	(Astr)	H 144"		Comments:
Water's ss		Alum	Side	Glaz W		
Light Industrial Bldg	VL	St	Head	H		
Testable (Yes/No	Sl	FG	Sect	#		
Photo No.	Roll	Plast	Trail Seal		Dock Level	
Frame Width 8"	Sw	Insul	Dock Shelt		Grade 4	

Bldg No. (doors)	Type	Mat'l	Seal	Door W		Condition Scale (B 2 3 4 5 6 7 8 9 G)
	SO	Wd	Astr	H		Comments:
		Alum	Side	Glaz W		
	VL	St	Head	H		
Testable Yes/No	Sl	FG	Sect	#		
Photo No.	Roll	Plast	Trail Seal		Dock Level	
Frame Width	Sw	Insul	Dock Shelt		Grade	

Codes: SO - Sectional Overhead
VL - Vertical Lift
Sl - Sliding
Roll - Rolling
Sw - Swinging

Wd - Wooden
Alum - Aluminum
St - Steel
FG - Fibre-glass
Plast - Plastic
Insul - Insulation

Astr - Astragal
Head - Header
Sect - Sectional
Trail Seal - Trailer Seals
Dock Shelt - Dock Shelters

Glaz - Glazing
- Number of Glazings
Dock Level - Dock Levelers
Grade - Grade Level
(ramped, at, above
↓ — ↑)

APPENDIX C

Door Survey Data

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C1: TABLE OF TYPE BY MATERIAL

TYPE MATERIAL

FREQUENCY PERCENT ROW PCT COL PCT	ALUMINUM	FIBRE GLASS	STEEL	WOOD	TOTAL
ROLLING	17 5.35 48.57 100.00	0 0.00 0.00 0.00	18 5.66 51.43 64.29	0 0.00 0.00 0.00	35 11.01
FLUSH SECTIONAL	0 0.00 0.00 0.00	16 5.03 30.19 100.00	2 0.63 3.77 7.14	35 11.01 66.04 13.62	53 16.67
SLIDING	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	8 2.52 100.00 3.11	8 2.52
SECTIONAL OVERHE	0 0.00 0.00 0.00	0 0.00 0.00 0.00	3 0.94 1.40 10.71	211 66.35 98.60 82.10	214 67.30
SWINGING	0 0.00 0.00 0.00	0 0.00 0.00 0.00	1 0.31 25.00 3.57	3 0.94 75.00 1.17	4 1.26
VERTICAL LIFT	0 0.00 0.00 0.00	0 0.00 0.00 0.00	4 1.26 100.00 14.29	0 0.00 0.00 0.00	4 1.26
TOTAL	17 5.35	16 5.03	28 8.81	257 80.82	318 100.00

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C2:TABLE OF TYPE BY HEADSEAL

TYPE HEADSEAL

FREQUENCY PERCENT ROW PCT COL PCT	HEADER SEAL	TOTAL
ROLLING	35 11.01 100.00 14.40	0 0.00 0.00 0.00	35 11.01
FLUSH SECTIONAL	36 11.32 67.92 14.81	17 5.35 32.08 22.67	53 16.67
SLIDING	2 0.63 25.00 0.82	6 1.89 75.00 8.00	8 2.52
SECTIONAL OVERHE	162 50.94 75.70 66.67	52 16.35 24.30 69.33	214 67.30
SWINGING	4 1.26 100.00 1.65	0 0.00 0.00 0.00	4 1.26
VERTICAL LIFT	4 1.26 100.00 1.65	0 0.00 0.00 0.00	4 1.26
TOTAL	243 76.42	75 23.58	318 100.00

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

CB: TABLE OF TYPE BY SIDESEAL

TYPE SIDESEAL

FREQUENCY PERCENT ROW PCT COL PCT	SIDE SEAL		TOTAL
ROLLING	18 5.66 51.43 8.14	17 5.35 48.57 17.53	35 11.01
PLUSH SECTIONAL	36 11.32 67.92 16.29	17 5.35 32.08 17.53	53 16.67
SLIDING	2 0.63 25.00 0.90	6 1.89 75.00 6.19	8 2.52
SECTIONAL OVERHE	157 49.37 73.36 71.04	57 17.92 26.64 58.76	214 67.30
SWINGING	4 1.26 100.00 1.81	0 0.00 0.00 0.00	4 1.26
VERTICAL LIFT	4 1.26 100.00 1.81	0 0.00 0.00 0.00	4 1.26
TOTAL	221 69.50	97 30.50	318 100.00

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C4:TABLE OF TYPE BY ASTRAGAL

TYPE ASTRAGAL

FREQUENCY PERCENT ROW PCT COL PCT		ASTRAGAL	TOTAL
ROLLING	14 4.40 40.00 50.00	21 6.60 60.00 7.24	35 11.01
FLUSH SECTIONAL	1 0.31 1.89 3.57	52 16.35 98.11 17.93	53 16.67
SLIDING	2 0.63 25.00 7.14	6 1.89 75.00 2.07	8 2.52
SECTIONAL OVERHE	9 2.83 4.21 32.14	205 64.47 95.79 70.69	214 67.30
SWINGING	2 0.63 50.00 7.14	2 0.63 50.00 0.69	4 1.26
VERTICAL LIFT	0 0.00 0.00 0.00	4 1.26 100.00 1.38	4 1.26
TOTAL	28 8.81	290 91.19	318 100.00

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C5: TABLE OF TYPE BY SECTSEAL

TYPE SECTSEAL

FREQUENCY PERCENT ROW PCT COL PCT	SECTIONAL SEAL	TOTAL
ROLLING	35 11.01 100.00 11.04	0 0.00 0.00 0.00	35 11.01
FLUSH SECTIONAL	53 16.67 100.00 16.72	0 0.00 0.00 0.00	53 16.67
SLIDING	8 2.52 100.00 2.52	0 0.00 0.00 0.00	8 2.52
SECTIONAL OVERHE	214 67.30 100.00 67.51	0 0.00 0.00 0.00	214 67.30
SWINGING	3 0.94 75.00 0.95	1 0.31 25.00 100.00	4 1.26
VERTICAL LIFT	4 1.26 100.00 1.26	0 0.00 0.00 0.00	4 1.26
TOTAL	317 99.69	1 0.31	318 100.00

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C6: TABLE OF TYPE BY TRSEAL

TYPE TRSEAL

FREQUENCY PERCENT ROW PCT COL PCT	TRAILER SEAL	TOTAL
ROLLING	35 11.01 100.00 15.02	0 0.00 0.00 0.00	35 11.01
FLUSH SECTIONAL	5 1.57 9.43 2.15	48 15.09 90.57 56.47	53 16.67
SLIDING	8 2.52 100.00 3.43	0 0.00 0.00 0.00	8 2.52
SECTIONAL OVERHE	177 55.66 82.71 75.97	37 11.64 17.29 43.53	214 67.30
SWINGING	4 1.26 100.00 1.72	0 0.00 0.00 0.00	4 1.26
VERTICAL LIFT	4 1.26 100.00 1.72	0 0.00 0.00 0.00	4 1.26
TOTAL	233 73.27	85 26.73	318 100.00

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C7: TABLE OF TYPE BY DKSHELT

TYPE DKSHELT

FREQUENCY PERCENT ROW PCT COL PCT	DOCK SHELTER	TOTAL
ROLLING	33 10.38 94.29 10.75	2 0.63 5.71 18.18	35 11.01
FLUSH SECTIONAL	53 16.67 100.00 17.26	0 0.00 0.00 0.00	53 16.67
SLIDING	8 2.52 100.00 2.61	0 0.00 0.00 0.00	8 2.52
SECTIONAL OVERHE	205 64.47 95.79 66.78	9 2.83 4.21 81.82	214 67.30
SWINGING	4 1.26 100.00 1.30	0 0.00 0.00 0.00	4 1.26
VERTICAL LIFT	4 1.26 100.00 1.30	0 0.00 0.00 0.00	4 1.26
TOTAL	307 96.54	11 3.46	318 100.00

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C8: TABLE OF TYPE BY TEST

TYPE TEST

FREQUENCY PERCENT ROW PCT COL PCT	UNTESTABLE	TESTABLE	TOTAL
ROLLING	16 5.03 45.71 10.32	19 5.97 54.29 11.66	35 11.01
FLUSH SECTIONAL	33 10.38 62.26 21.29	20 6.29 37.74 12.27	53 16.67
SLIDING	4 1.26 50.00 2.58	4 1.26 50.00 2.45	8 2.52
SECTIONAL OVERHE	94 29.56 43.93 60.65	120 37.74 56.07 73.62	214 67.30
SWINGING	4 1.26 100.00 2.58	0 0.00 0.00 0.00	4 1.26
VERTICAL LIFT	4 1.26 100.00 2.58	0 0.00 0.00 0.00	4 1.26
TOTAL	155 48.74	163 51.26	318 100.00

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C9: TABLE OF TYPE BY DOORHT

TYPE DOORHT

FREQUENCY PERCENT ROW PCT COL PCT	<7	8	10	12	14	16	>20	TOTAL
ROLLING	0 0.00 0.00 0.00	0 0.00 0.00 0.00	14 4.40 40.00 12.17	17 5.35 48.57 23.94	3 0.94 8.57 20.00	0 0.00 0.00 0.00	1 0.31 2.86 50.00	35 11.01
PLUSH SECTIONAL	21 6.60 39.62 95.45	9 2.83 16.98 11.25	20 6.29 37.74 17.39	2 0.63 3.77 2.82	1 0.31 1.89 6.67	0 0.00 0.00 0.00	0 0.00 0.00 0.00	53 16.67
SLIDING	0 0.00 0.00 0.00	4 1.26 50.00 5.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	4 1.26 50.00 26.67	0 0.00 0.00 0.00	0 0.00 0.00 0.00	8 2.52
SECTIONAL OVERHE	0 0.00 0.00 0.00	66 20.75 30.84 82.50	81 25.47 37.85 70.43	50 15.72 23.36 70.42	7 2.20 3.27 46.67	9 2.83 4.21 69.23	1 0.31 0.47 50.00	214 67.30
SWINGING	1 0.31 25.00 4.55	1 0.31 25.00 1.25	0 0.00 0.00 0.00	2 0.63 50.00 2.82	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	4 1.26
VERTICAL LIFT	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	4 1.26 100.00 30.77	0 0.00 0.00 0.00	4 1.26
TOTAL	22 6.92	80 25.16	115 36.16	71 22.33	15 4.72	13 4.09	2 0.63	318 100.00

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C10: TABLE OF TYPE BY DOORWDTH

TYPE DOORWDTH

FREQUENCY PERCENT ROW PCT COL PCT	<7	8	10	12	14	16	18	>20	TOTAL
ROLLING	0 0.00 0.00 0.00	14 4.40 40.00 7.95	17 5.35 48.57 21.79	3 0.94 8.57 11.54	1 0.31 2.86 20.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	35 11.01
FLUSH SECTIONAL	21 6.60 39.62 77.78	29 9.12 54.72 16.48	1 0.31 1.89 1.28	0 0.00 0.00 0.00	1 0.31 1.89 20.00	0 0.00 0.00 0.00	1 0.31 1.89 100.00	0 0.00 0.00 0.00	53 16.67
SLIDING	3 0.94 37.50 11.11	0 0.00 0.00 0.00	0 0.00 0.00 0.00	3 0.94 37.50 11.54	0 0.00 0.00 0.00	2 0.63 25.00 66.67	0 0.00 0.00 0.00	0 0.00 0.00 0.00	8 2.52
SECTIONAL OVERHE	2 0.63 0.93 7.41	132 41.51 61.68 75.00	58 18.24 27.10 74.36	18 5.66 8.41 69.23	3 0.94 1.40 60.00	1 0.31 0.47 33.33	0 0.00 0.00 0.00	0 0.00 0.00 0.00	214 67.30
SWINGING	1 0.31 25.00 3.70	1 0.31 25.00 0.57	2 0.63 50.00 2.56	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	4 1.26
VERTICAL LIFT	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	2 0.63 50.00 7.69	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	2 0.63 50.00 100.00	4 1.26
TOTAL	27 8.49	176 55.35	78 24.53	26 8.18	5 1.57	3 0.94	1 0.31	2 0.63	318 100.00

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C11: TABLE OF TYPE BY GLAZ

TYPE GLAZ

FREQUENCY PERCENT ROW PCT COL PCT	NIL	1	2	TOTAL
ROLLING	35 11.01 100.00 15.70	0 0.00 0.00 0.00	0 0.00 0.00 0.00	35 11.01
FLUSH SECTIONAL	30 9.43 56.60 13.45	23 7.23 43.40 24.73	0 0.00 0.00 0.00	53 16.67
SLIDING	8 2.52 100.00 3.59	0 0.00 0.00 0.00	0 0.00 0.00 0.00	8 2.52
SECTIONAL OVERHE	147 46.23 68.69 65.92	66 20.75 30.84 70.97	1 0.31 0.47 50.00	214 67.30
SWINGING	3 0.94 75.00 1.35	0 0.00 0.00 0.00	1 0.31 25.00 50.00	4 1.26
VERTICAL LIFT	0 0.00 0.00 0.00	4 1.26 100.00 4.30	0 0.00 0.00 0.00	4 1.26
TOTAL	223 70.13	93 29.25	2 0.63	318 100.00

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C12: TABLE OF TYPE BY GRADE

TYPE GRADE

FREQUENCY PERCENT ROW PCT COL PCT	ABOVE GRADE LOAD	AT GRADE ENTRANC	BELOW GRADE LOAD	TOTAL
ROLLING	22 6.92 62.86 9.28	13 4.09 37.14 18.57	0 0.00 0.00 0.00	35 11.01
FLUSH SECTIONAL	50 15.72 94.34 21.10	3 0.94 5.66 4.29	0 0.00 0.00 0.00	53 16.67
SLIDING	0 0.00 0.00 0.00	6 1.89 75.00 8.57	2 0.63 25.00 18.18	8 2.52
SECTIONAL OVERHE	163 51.26 76.17 68.78	43 13.52 20.09 61.43	8 2.52 3.74 72.73	214 67.30
SWINGING	2 0.63 50.00 0.84	1 0.31 25.00 1.43	1 0.31 25.00 9.09	4 1.26
VERTICAL LIFT	0 0.00 0.00 0.00	4 1.26 100.00 5.71	0 0.00 0.00 0.00	4 1.26
TOTAL	237 74.53	70 22.01	11 3.46	318 100.00

SURVEY OF INSTALLED SHIPPING DOORS

BUILDING ENGINEERING GROUP

FREQUENCY ANALYSIS

C13: TABLE OF TYPE BY DKLEVEL

TYPE DKLEVEL

FREQUENCY PERCENT ROW PCT COL PCT	.	DOCK LEVELER	TOTAL
ROLLING	33 10.38 94.29 14.73	2 0.63 5.71 2.13	35 11.01
FLUSH SECTIONAL	36 11.32 67.92 16.07	17 5.35 32.08 18.09	53 16.67
SLIDING	6 1.89 75.00 2.68	2 0.63 25.00 2.13	8 2.52
SECTIONAL OVERHE	142 44.65 66.36 63.39	72 22.64 33.64 76.60	214 67.30
SWINGING	3 0.94 75.00 1.34	1 0.31 25.00 1.06	4 1.26
VERTICAL LIFT	4 1.26 100.00 1.79	0 0.00 0.00 0.00	4 1.26
TOTAL	224 70.44	94 29.56	318 100.00